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FACTORS INFLUENCING RAPID PROTOTYPING
INNOVATION IMPLEMENTATION:
A DESCRIPTIVE MODEL

by

Tammy L. Davis

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Thesis Advisor:

Richard A. McGonigal

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direction for timely integration of future innovative efforts through rapid prototyping.

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Factors Influencing Rapid Prototyping Innovation
Implementation: A Descriptive Model

by

Tammy L. Davis
Lieutenant, United States Navy
B.S., United States Naval Academy, 1985

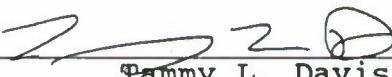
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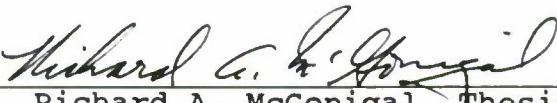
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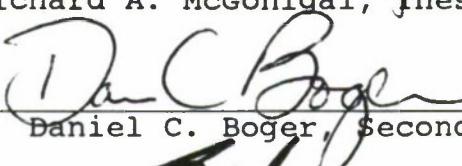
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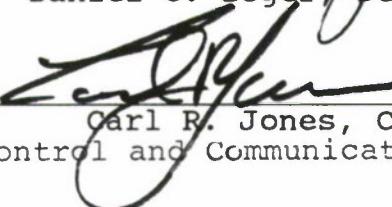
Author:


Tammy L. Davis

Approved by:


Richard A. McGonigal, Thesis Advisor


Daniel C. Boger, Second Reader


Carl R. Jones, Chairman
Command, Control and Communications Academic Group

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ABSTRACT

This thesis examines the factors that influence rapid prototyping innovation implementation. Research was conducted to develop a qualitative, descriptive model of factors influencing user acceptance and organization implementation. The model reflected a review of the literature on innovation acceptance, implementation of change, human factors in technology transfer, and organizational development; a review of related Navy-specific findings and the elements of rapid prototyping; a case study of Inter-National Research Institute's Joint Operational Tactical System evolution as a real world example; and interviews and correspondence with personnel representing "players" in the development and utilization process. This model is useful in structuring thinking about the problems of innovation implementation, identifying areas where future research on the acceptance process may have the greatest impact, and may be extended to provide direction for timely integration of future innovative efforts through rapid prototyping.

TABLE OF CONTENTS

I.	INTRODUCTION -----	1
	A. THE PROBLEM -----	2
	B. TOWARD A SOLUTION -----	12
II.	LITERATURE REVIEW -----	15
	A. IMPLEMENTATION OF CHANGE -----	15
	B. DIFFUSION, ADOPTION, ACCEPTANCE OF INNOVATION -----	16
	C. INFORMATION LINKER MODEL -----	25
	D. ORGANIZATIONAL MODELS OF INNOVATION -----	34
	E. MANAGEMENT'S ROLE IN INNOVATION -----	41
	F. HUMAN FACTORS IN TECHNOLOGY TRANSFER -----	47
	G. GENERAL REVIEW SUMMARY -----	50
	H. NAVY SPECIFICS -----	53
III.	CASE STUDY BACKGROUND -----	59
	A. INRI HISTORY -----	59
	B. JOTS EVOLUTION -----	62
	C. BARRIERS INCURRED -----	71
IV.	RAPID PROTOTYPING: ELEMENTS OF SUCCESS -----	77
	A. TOP-LEVEL SUPPORT -----	79
	B. DEVELOPER/USER LIAISON -----	83
	C. CONFIGURATION MANAGEMENT -----	87
	D. AGGRESSIVE USER SUPPORT -----	90
	E. COORDINATION AND PLANNING -----	91
	F. ACCELERATED PROCUREMENT CYCLE -----	91

G.	ACCEPTANCE TESTING CRITERIA/PROGRAM -----	92
H.	INSTALLATION/MAINTENANCE SUPPORT PACKAGE -----	92
I.	TRAINING/IMPLEMENTATION -----	93
J.	LIFECYCLE SUPPORT FOR MAINTENANCE/ TROUBLESHOOTING/UPGRADING -----	93
V.	DESCRIPTIVE INNOVATION IMPLEMENTATION MODEL -----	95
A.	INDIVIDUAL/ORGANIZATION COMPONENT -----	96
B.	FEATURE EVALUATION COMPONENT -----	99
C.	DYNAMIC INTERACTION COMPONENT -----	101
D.	INTERPRETATION AND ANALYSIS -----	103
VI.	CONCLUSIONS AND RECOMMENDATIONS -----	109
LIST OF REFERENCES -----		112
INITIAL DISTRIBUTION LIST -----		118

I. INTRODUCTION

Command and control (C2) is a process that takes place within a structure at many levels. At higher levels, policy consequences generally dominate the approach taken to obtain a decision, while at lower levels survival and effectiveness provide the bounds for decision making. Regardless of the level, the following excerpt from the 1987 Defense Science Board Task Force on C2 System Management can generally be applied to any command and control system:

A command and control system supporting a commander is not just a computer with its associated software and displays; it is not just communications links; and it is not even just all the information processing and fusion that must go into any well-designed and well-operating command and control system. It is all of the above and much more. The ideal command and control system supporting a commander is such that the commander knows what is going on, that he receives what is intended for him and that what he transmits is delivered to the intended addressee, so that the command decisions are made with confidence and are based on information that is complete, true, and up-to-date. The purpose of a command and control system is, in the end, to provide assurance that orders are received as originally intended with follow-up in a timely fashion, which can make the difference between winning and losing wars. (Defense Science Board Task Force, 1987, p. 13)

The concept of integrated battlefield command and control is not new and has always been an important objective. In order to capitalize on the high state of training and the resultant readiness level of our forces, a system must be emplaced and procedurally implemented to assist the

operational commander by giving him the ability to rapidly assimilate and digest the deluge of information available.

Data fusion as a machine-aided, data reduction process for integrating reports from all available and appropriate sources (friendly and enemy) develops a coherent display of a commander's area of interest to assist in command, control, communications, and intelligence (C3I) functions. Such a system is designed to provide the commander with a reliable means of perceiving the environment while allowing him to effectively plan, direct, and control the actions of his forces. It must provide the CINC and his subordinates with near real time data displays of friendly and enemy dispositions while preserving personnel resources and allowing friendly force commanders the enhanced capability of analyzing data as opposed to handling data.

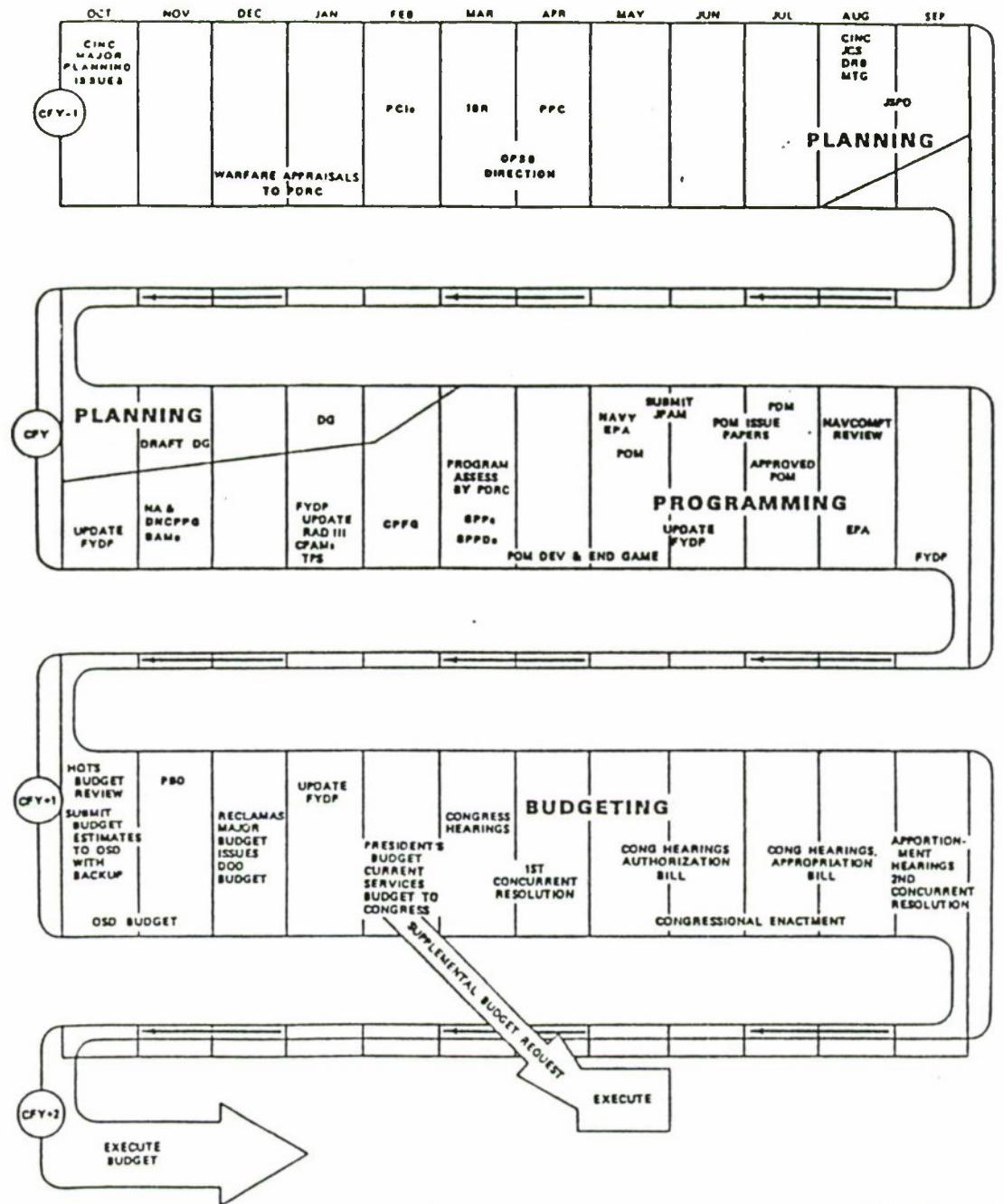
A. THE PROBLEM

With the rapid growth of "expert" systems, the increasing interest in development of "artificial intelligence" systems, and the feeling that the next war will be won by the power with the most advanced computers, it is becoming quite evident that the development of faster and better computer systems will be a major developmental race of the next decade. The rapid rate at which computer science has gone from chips to mini-chips to micro-chips, from a few bytes of memory to millions of bytes, and from minutes to micro-seconds of

reaction time is leading to new and unorthodox developmental philosophies.

Under the current procurement process as described in the Navy Program Manager's Guide (NPMG, 1988), major decisions for individual projects/programs are made in the context of both the acquisition process and the Planning, Programming, Budgeting System (PPBS). The acquisition process proceeds in phases, each of which may require only a part of a budget cycle or several full cycles. Gearing the phases to the particular business and technical aspects of the program attempts to ensure that adequate in-depth reviews are conducted prior to significant commitment of resources. By contrast, the PPBS runs on a tightly structured schedule. A single cycle from initial planning through congressional enactment to actual execution requires 25 months. The PPBS decisions, rather than being oriented to the needs of a specific program, are keyed to the larger problem of balancing all of the programs within the Department of the Navy (DoN), Department of Defense (DoD), Office of Management and Budget (OMB), and congressional financial limits established for a particular fiscal year of the Five Year Defense Plan (FYDP). The sequence of PPBS events is shown in Figure 1 (NPMG, 1988, p. 3-12).

The Department of the Navy system acquisition process normally consists of five phases which are separated by decision milestones as shown in Figure 2. The phases are



BAH	Baseline Budget Assessment	JSPD	Joint Strategic Planning Document
CPFQ	Consolidated Program and Fiscal Guidance	NA	Net Assessment
DG	Defense Guidance	PBD	Program Budget Decision
DNCPG	DDN Consolidated Planning & Programming Guidance	PDM	Program Decision Memorandum
DPSB	DDN Program Strategy Board	PDRC	Program Development Review Committee
DRB	Defense Resources Board	POM	Program Objectives Memorandum
EPA	Extended Planning Annex	PPC	Proposed Program Change
FYDP	Five-Year Defense Program	SPP	Sponsor Program Proposal
ISR	Investment Strategy Review	SPPD	Sponsor Program Proposal Decision Document
JPAM	Joint Program Assessment Memorandum		

Figure 1. Sequence of PPBS Events

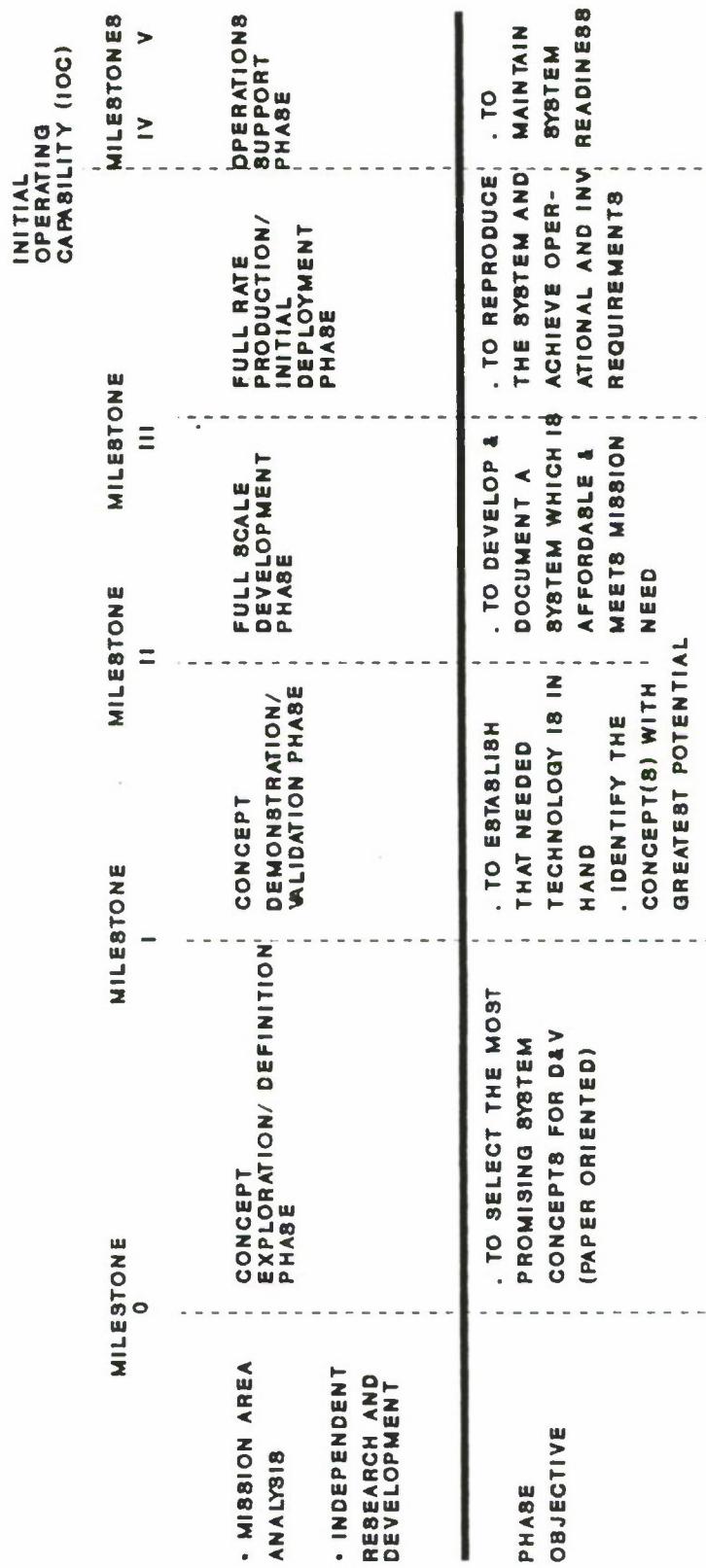


Figure 2. Acquisition Decision Milestones

tailored to fit each program's specific requirements of time, cost, need, and degree of technical risk. The acquisition process, though conceptually simple, is detailed in its requirements as evident in Table 1 which lists the documentation requirements scheduled at each milestone of the acquisition process.

The effect of the interrelationship between the PPBS and an acquisition program is that adequate funding for the critical concept exploration/definition phase of the acquisition process is unlikely to occur until 18 to 24 months after the need document submittal and at least 12 months after its approval. (NPMG, 1988, p. 3-12)

At one time, military procurement had to develop items from scratch in order to take advantage of state-of-the-art technology. Today, the military can take advantage of state-of-the-art technology driven by commercial application by use of the Non-Developmental Item (NDI) strategy. NDI can be considered as a balance of risk and technological advancement allowing the services to have a system in the field into the users' hands via a reduced timeline.

An NDI approach is beneficial for both the government and the contractor in that it allows the government to forego a lengthy research and development cycle while reducing the possibility of a poor return for industry. Comparing the NDI cycle with the traditional acquisition cycle, the savings in funding are immediately obvious. There are, however, certain risks involved when the decision is made to utilize the NDI strategy.

TABLE 1

ACQUISITION DOCUMENTATION REQUIREMENTS

MILESTONE
DOCUMENTATION:

0:	<ul style="list-style-type: none"> • MNS (PROGRAM BASELINE) • COD • ICE • ADM 	<ul style="list-style-type: none"> • SCP (ANNEX B IS PROGRAM BASELINE) • TEMP • COEA • CUAS • CPS • COD • ICE • ASR • ADM 	<ul style="list-style-type: none"> • DCP • DB • MER • ASR • COEA • CUAS • TEMP • COD • ICE • ADM 	<ul style="list-style-type: none"> • DCP • PB • LRIP • MER • ASR • ASR • TEMP • COD • ICE • ADM 	<ul style="list-style-type: none"> • DCP • PB • TEMP • ICE • COD • ADM 	<ul style="list-style-type: none"> • DCP • PB • TEMP • ICE • COD • ADM
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LEGEND:

ADM: ACQUISITION DECISION MEMORANDUM
 ASR: ACQUISITION STRATEGY REPORT
 COD: COOPERATIVE OPPORTUNITIES DOCUMENT
 COEA: COST & OPERATIONAL EFFECTIVENESS ANALYSIS
 CPS: COMPETITIVE PROTOTYPING STRATEGY
 CUAB: COMMON USE ALTERNATIVES STATEMENTS
 DB: DEVELOPMENT BASELINE
 DCP: DECISION COORDINATING PAPER

ICE: INDEPENDENT COST ESTIMATE
 LRIP: LOW RATE INITIAL PRODUCTION
 MER: MANPOWER ESTIMATE REPORT
 MNS: MISSION NEEDS STATEMENT
 PB: PRODUCTION BASELINE
 SCP: SYSTEM CONCEPT PAPER
 TEMP: TEST & EVALUATION MASTER PLAN

One consideration that can be easily overlooked is the impact on both interoperability and supportability. The logistical support for an NDI system must be carefully thought out, especially software support during deployments. An additional supportability pitfall could conceivably occur in that the speed of the NDI acquisition process may surpass the standard Integrated Logistics Support (ILS) process. It does no good to deliver an item that cannot be operated or maintained due to a lack of training or tools or cannot be repaired due to a lack of spare parts.

NDI allows the driving factor of "urgency of need" to be carried into the source selection process. Depicted in Figure 3 is a representation of how the standard acquisition cycle differs from NDI. As can be seen, NDI can save a considerable amount of time in the acquisition cycle of a system. Although the entire cycle is portrayed, the real difference occurs in the middle two phases. The standard acquisition cycle has a concept exploration/definition phase which leads into demonstration and validation, full scale development, and finally into production and deployment. In NDI, the demonstration and validation phase and the full scale development phase are combined into one phase; this phase is referred to as the acquisition demonstration phase. During this time, the Request for Proposal (RFP) is prepared and proposals are received and evaluated.

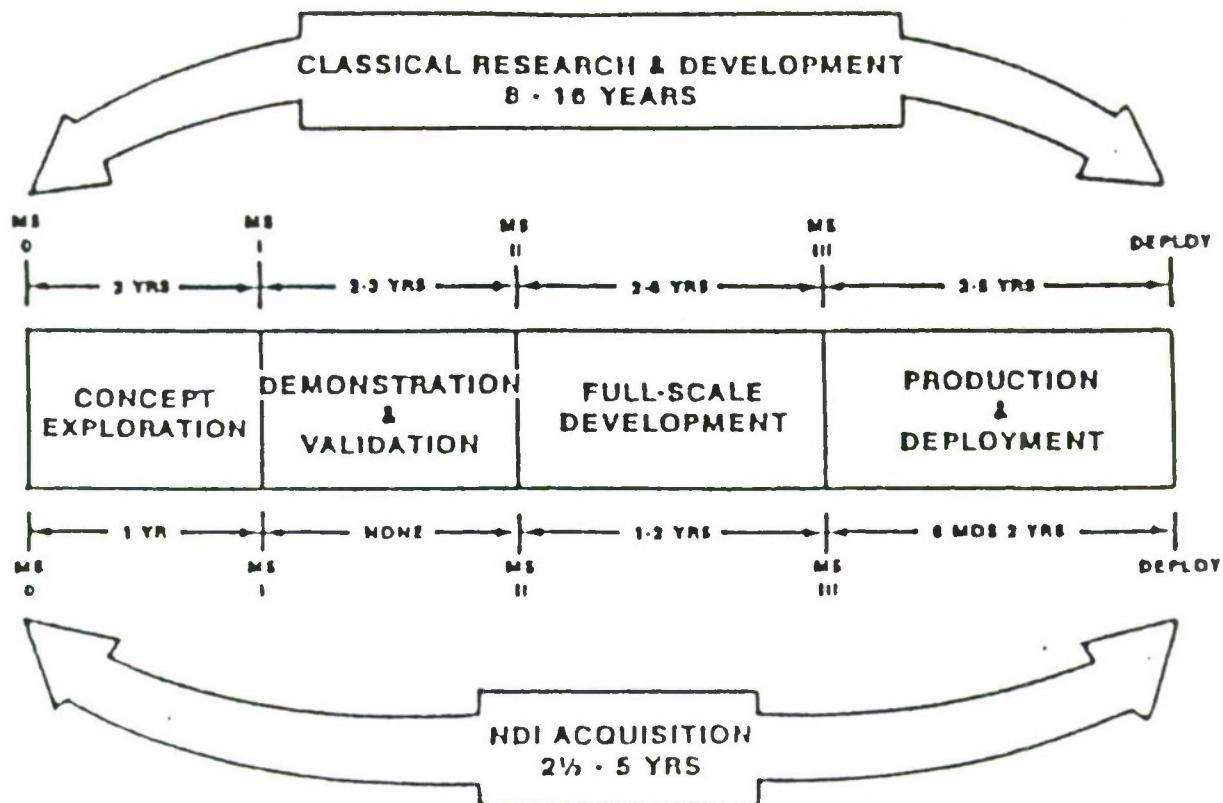


Figure 3. Classical vs. NDI Acquisition Cycle

Another method available to reduce the overall procurement timeline of a new system is utilization of a PrePlanned Product Improvement (P3I) plan. The time from inception of a system to initial operational capability (IOC) is often inordinately long due to the approval process, single-year funding, the increasing complexity of modern systems, and a desire on the part of system designers and sponsors to develop an all-purpose end product. "However, a system that will perform 90% or more of the mission goals can often be designed in far less than 90% of the time necessary to achieve all of

the goals." (NPMG, 1988, p. 1-11) A P3I plan facilitates this trade-off between time and performance while allowing for earlier Fleet introduction of needed capabilities and reducing program risk.

P3I, an acquisition concept that encourages orderly, time-phased introduction of incremental system capability, can accommodate projected changes in threat and reduce the risk inherent in fielding a system that is dependent on unproven technology. The concept involves programming resources in order to accomplish scheduled, cost-effective evolution of a system's capability, utility, and operational readiness. Thus, P3I minimizes the technical risk of fielding a new system while reducing the potential for delayed Fleet introduction that is posed by using new technology to meet a military threat.

Besides shortening the inception-to-IOC time, P3I may tend to make program sponsors more receptive to criticism of system shortcomings. "By planning the growth from the initial design stages, P3I permits development of a system that is receptive to modification in response to downstream threat definition changes and future technology development." (NPMG, 1988, p. 1-12)

The U.S. military no longer must go through the long, tedious series of events required by the peacetime research and development and service approval process. By the time a modern system is fielded under the traditional process, it

may, in fact, be obsolete. Instead, a system can be developed, fielded, and evaluated by the fleet in conjunction with fleet introduction (Interim Service Approval).

Rapid prototyping conceptually represents the best of both of the time-reduced fleet introduction techniques addressed--NDI and P3I. A proven, "no-frills" system design is quickly introduced to the fleet satisfying an urgency of need with the intent of system modification through incremental capability upgrades. Rapid prototyping is a method of demonstrating a proof of concept with user participation throughout design and development of a system based on requirements as they emerge rather than on theoretical needs.

There appears to be a place for this rapid evolution of a system from developer to end user in the software intensive area of C3. The question is, given the existence of the needed level of advanced technology, how is rapid operational capability realized? Both high and low context factors play a role which must be considered. Low context factors are those that are explicit, such as the written instruction, and are easily explained. High context factors, on the other hand, are unexplained and subjective, therefore are much harder to analyze and nearly impossible to quantify (Hall, 1977, pp. 105-116). An effort to explain how an innovation implementation scheme is realized must consider as many of these factors as feasible in order to truly understand why/how that innovation is adopted quickly, eventually, or not at all.

B. TOWARD A SOLUTION

The purpose of this study is to develop an understanding of the individual, group, organizational, and dynamic factors that determine the acceptance and optimal utilization of innovations in advanced technology. Many systems and/or devices, especially those involving new technology, will likely pose problems of innovation acceptance on the part of both individuals and Navy organizations.

Very few noteworthy examples exist of successful incorporation of operational leading-edge technology in the fleet today. Not many major systems are introduced into the fleet by other than the conventional, lengthy acquisition cycle of the explicit milestone and phase developmental process. However, one current embodiment of advanced technology enjoying apparent success is the rapid prototyping of the Joint Operational Tactical System (JOTS).

The JOTS story and the development of the rapid prototyping concept are a deviation from the current trends toward a more institutionalized structure for acquisition of defense systems, with particular emphasis on personnel who are acquisition specialists. The classic systems development concept has been a pattern of the operators developing the requirement, providing the funding, then turning it over to a material activity to develop the system needed to meet the requirements with varying levels of user participation during

development. This procedure works well some of the time but often fails in C3I and other software-intensive warfare areas.

While the defense organization creates an acquisition hierarchy that nearly excludes user or operator involvement once the requirement and the program have been established, JOTS and rapid prototyping point in the opposite direction. Both approaches have valid arguments and justification. It is not a case of one approach being right and the other wrong for every system. "They are both right, and a means to resolve the shortcomings of each technique must be found." (Lake, 1989, p. 21)

A product of this study is a qualitative, descriptive model of factors influencing the innovation implementation process based on:

- (1) results of studies previously conducted on innovation acceptance issues.
- (2) data from comprehensive interviews with various "players" in the innovation and acceptance process.
- (3) previous theoretical modeling of organizational change and innovation acceptance.

Hopes are that this JOTS-based model may be adequately extended to provide direction for timely integration of future innovative efforts through rapid prototyping.

The next chapter summarizes useful concepts from a review of the literature on implementation of change, innovation acceptance, organizational models of innovation, human factors in technology transfer, and Navy specific research transitioning issues. Chapter III provides an overview of the

background of the system, JOTS, and the developer, INRI, including those barriers incurred while attempting implementation of this C3 innovation in the fleet. Chapter IV describes JOTS rapid prototyping elements of success as a special case of the general problem of innovation acceptance. Chapter V presents and interprets the JOTS rapid prototyping, innovation implementation model incorporating relevant literature and case study analysis which was has been developed. Chapter VI provides conclusions and recommendations.

II. LITERATURE REVIEW

The purpose of this chapter is to provide a perspective for the study of planned organization change by examining the major issues raised in the related literature. First, consideration is given to the application of principles derived from the studies of diffusion, acceptance, and adoption of innovation and some prominent themes that run through the literature on initiation of organizational innovations based on a 1983 Navy Personnel Research and Development Center (NPRDC) study and others as noted. Next, the emphasis is on management's role in innovation and human factors issues in the transfer of technology. And finally, the focus is on previous Navy specific implementation-of-change studies and speculative papers that focus on the implementation phase of the change process.

A. IMPLEMENTATION OF CHANGE

The innovation process is generally recognized as having three ordered phases: initiation, implementation, and institutionalization. The initiation phase encompasses the conceptualization of the innovation and the search, evaluation, selection, and decision to adopt or reject. This phase may either begin with awareness of a performance gap identifying a discrepancy to which the organization needs to respond, as was the case with JOTS, or alternatively,

awareness of an innovation that may stimulate a need or desire to adopt.

The implementation phase begins with the initial attempt to introduce and integrate the innovation into the organization. This phase is concerned with the actual use of the innovation by the members of the adopting unit as the project confronts the reality of the organizational setting. The focus of this phase is to change the behavior of the adopting group to that specified by the innovation.

The institutionalization phase, following a successful implementation phase, is concerned with the sustenance of the change. Such routinization (Hage and Aiken, 1970) or incorporation (Gross et al., 1971) occurs when the behavior specified becomes an accepted, routine, and enduring part of the standard repertoire of the organization for the necessary percentage of personnel who will sustain the innovation.

B. DIFFUSION, ADOPTION, ACCEPTANCE OF INNOVATION

Current thinking about the innovation process has been strongly influenced by Rogers' (1962) early work on diffusion and adoption of innovations. Reviewing over 500 studies, Rogers constructed a classification scheme detailing stages in the adoption process, characteristics of innovations and early and late adopters, and rates of adoption. His five-stage model of the adoption process includes awareness, interest, trial, evaluation, and adoption, focusing mainly on preadoptive behavior. The overall conclusion of Rogers' work

is that a high adoptive rate is a function of the proven quality and value of the innovation, the extent to which it has readily demonstrable effects, the accessibility of information about it, and its cost (Miles, 1964). Davis (1971), Glaser (1973), and Havelock (1974) each list factors that may increase the likelihood of adoption of innovations. All three models essentially agree that the primary focus is on the preadoptive stage; the major barrier is the initial resistance by individuals; and effective change strategies must deal with the deficiencies that exist in the planning, communication, dissemination, quality and quantity of the available information.

"Given a perspective that concentrates on attitudinal and/or motivational readiness and organizational capacity for change, it follows that mechanisms geared to promote adoption of change are of pivotal importance." (NPRDC, 1983, p. 4) A professional who influences innovation decisions in the desired direction, a change agent, is one such mechanism. Sashkin et al. (1973) view the change agent's role as that of a "knowledge linker," a term to be discussed extensively in the Information Linker Model section. Greiner (1967) reports that change appears to be a consequence of an external change agent, particularly when the change agent is considered to be of high prestige and expertise. A change agent can influence those designated for change through coercion, persuasion, or

education, depending on factors such as the nature of the change target's resistance (Kotter and Schlesinger, 1979).

Another mechanism geared to promote adoption to change is the inclusion of subordinates in decisions concerning change. Being excluded from the decision making process may indicate to subordinates that they are not trusted or are being manipulated. This does not necessarily apply in military organizations where subordinate decision making participation is not a common occurrence or expectation, but is nonetheless a prevalent theme in the literature. However, it does follow that in any organization, participation generally leads to higher morale and greater commitment (Oliver, 1965; Bennis, 1966).

In a report prepared for the Organizational Effectiveness Research Group of the Office of Naval Research entitled Factors Influencing Organizational Acceptance of Technological Change in Training, Wylie and Mackie (1982) diagramed the dynamics of the innovation decision process as they hypothesized it might occur during the introduction of new training technology to the fleet. Their concept of the innovation process of new training devices and technologies is depicted in Figure 4 (Canyon Research Group, 1982, p. 7). An explanation of the diagram's components, in terms of the overall aspects (not training specific), could however apply to any case of innovation acceptance, including rapid prototyping of JOTS.

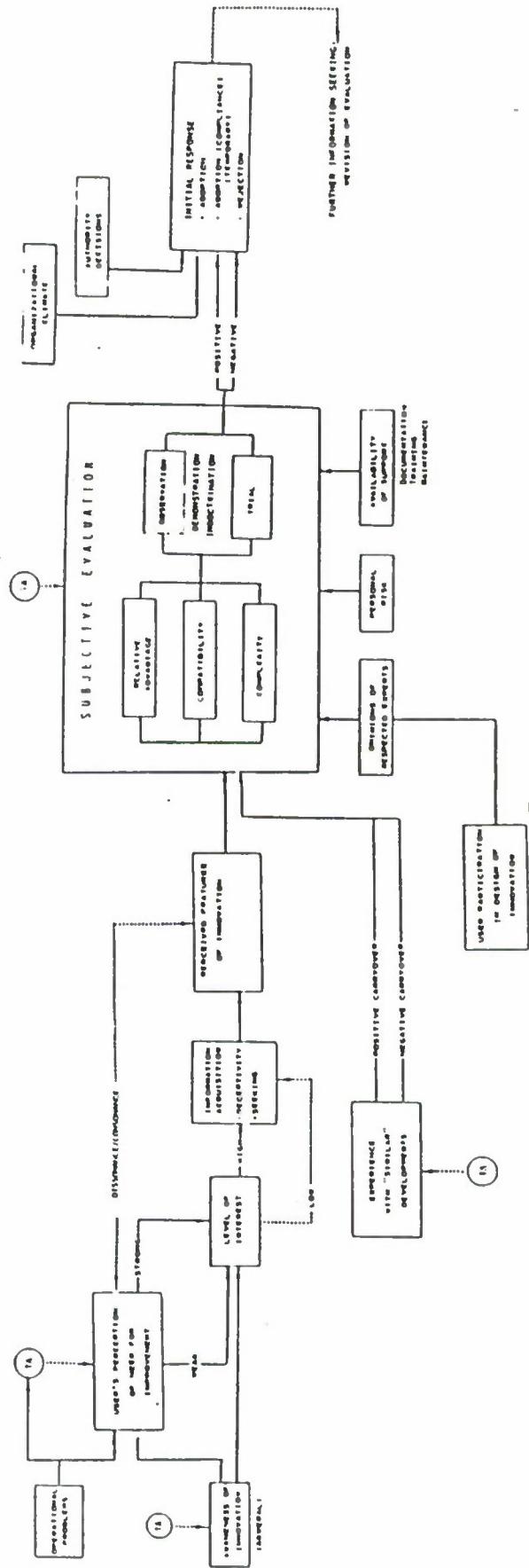


Figure 4. Concept of Innovation Process

Initial awareness of a new device or technique is stimulated in Navy personnel through a variety of formal and informal channels. Any distortions in this initial communication caused by inaccurate or incomprehensive information may serve to adversely impact the acceptance process.

The trainer advocate (TA) is modeled after the change advocate previously discussed. Dashed lines are used to show the TA's areas of impact because he is rarely, if ever, evident during the process of introducing new systems to military organizations (Canyon Research Group, 1982, p. 9).

Not all intended users will have the same appreciation for the operational problem which stimulated development of the new innovation. This, in part, is a consequence of high turnover rate among military personnel due to routine duty assignment rotation. If employed at this point, a TA could be the source of valid information concerning operational problems associated with the innovation development, as well as how the innovation is expected to aid in solving those problems.

Initial level of interest is a function of the user's perception of the need for improvement and knowledge of the purpose of the innovation. If the user's interest is at least high enough that the user remains receptive to further information about the innovation, even if not actively seeking it, the innovation process may proceed.

In the absence of authoritative messages, the user's general perception of the innovative system can be a function of informal channels of **information acquisition** through which the likelihood of misconceptions seem particularly high when the innovation is viewed as intrusive on other, more established procedures.

The user's early perception, based on varying degrees of detail concerning **features of the innovation**, is viewed as an interactive process. Subsequently received information can result in either increasing or decreasing the likeness between perceived need and perceived features (Canyon Research Group, 1982, p. 12).

Subjective evaluation is a primary determinant of innovation acceptance (Stoffer et al., 1980, Canyon Research Group, 1982). Several aspects of the process are included in Figure 4. The **relative advantage** of an innovation, or the degree to which it is perceived as better than that which it is intended to supercede, as viewed by the members of the user group, is positively related to its rate of adoption (Rogers and Shoemaker, 1971). However, relative advantage alone does not insure adoption as many other considerations enter into the acceptance-rejection decision. **Compatibility**, the degree to which an innovation is perceived to be consistent with the values, experiences and needs of the users, as well as operational compatibility with other systems with which the innovation must work is of concern to Navy personnel.

Complexity, the degree to which an innovation is perceived as relatively difficult to understand and use, is generally regarded as negatively related to its rate of adoption (Rogers and Shoemaker, 1971). **Observability**, the degree to which the results of the use of an innovation are visible to others, is likely to be particularly important in stimulating acceptance of innovations about which there is initial skepticism (Canyon Research Group, 1982). **Triability** is the degree to which an innovation may be experimented with by actual user personnel prior to making the decision to adopt or reject.

There are also a number of important external influences on subjective evaluation included in the diagram which are separate from the innovative device itself. Subjective evaluation of innovation development may be biased, positively or negatively, depending on whether **experience with prior developments** that are perceived as being similar to the proposed innovation was favorable or not. An innovation advocate, aware of the deficiencies of earlier systems viewed as belonging to the same general category as the new one, can play a critical role in countering any feeling that the new development will not be any better than the last.

User participation in design of an innovation may serve to extinguish any negative bias toward that innovation reflected by a "not invented here" disposition. As noted in other studies of innovation acceptance in the Navy, highly qualified users should, if at all possible, be involved in the design

process (Human Factors Research, Inc., 1970). Some degree of subjective personal risk to the potential user, if only in perceived threat to an established expertise, is encountered toward all innovations.

Any Navy system requires proper documentation and maintenance support. Wylie and Mackie view the significance of the availability of support as lying in the early formation of attitudes of acceptance or rejection based on the user's prior experience with the adequacy of the support functions. Following initial system implementation, continued support is absolutely essential to avoid temporary adoption followed by subsequent disuse or rejection. "It is an unfortunate commentary that some innovative Navy systems have fallen into disuse because of lack of adequate support despite the fact that they were developed to meet widely recognized needs." (Canyon Research Group, 1982, p. 21) "Corporate memory loss" fostered by the Navy system of personnel rotation and relatively short tours of duty may become readily apparent as a progressive deterioration in the level of sophistication with which the innovation is used indicates a lack of understanding of the reasons why a particular innovation was initially adopted.

The set of properties including size, structure, leadership pattern, interpersonal relationships, system complexity, goal direction and communication patterns is referred to as the climate of an organization. Citing Shein

(1970), Wylie and Mackie contend that a "healthy" organizational climate is one that:

- (1) receives and communicates information reliably and validly.
- (2) has the internal flexibility and creativity necessary to make changes which are demanded by information obtained.
- (3) possesses the willingness to change as derived from integration and commitment to the organization's goals.
- (4) provides internal support and freedom from threat in an effort not to undermine good communication, reduce flexibility, or promote self protectionism rather than concern for the total system.

Organizational climate is shown external to the subjective evaluation process because it is viewed as a "thresholding" influence which may affect the initial adoption/rejection response of an individual toward an innovation regardless of their personal subjective evaluation (Canyon Research Group, 1982, p. 23).

Authority decisions to adopt or reject are commonplace, particularly in the military. Still, the users inevitably evaluate the innovation in terms of their own personal operational needs. The authority decision will be complied with on the surface. However, compliance is not the same as adoption. With compliance, any change in behavior is often temporary requiring continued reinforcement to avoid gradual disuse or rejection.

In the early stage of the introduction of an innovation, the initial response to adopt or reject may be followed by further information seeking, evaluation revision in accordance

with new evidence, further consideration of alternatives, etc. Acceptance of an innovation will eventually be reflected in its organizational institutionalization.

C. INFORMATION LINKER MODEL

The Creighton and Jolly Information Linker Model describes information movement occurrences from source to receiver and has been the basis of many follow-on studies. The model divides knowledge flow enhancement factors into formal and informal elements (Figure 5). All of the factors to some degree affect the transfer mechanism. The formal factors are relatively manageable and identifiable, recognized as things to be administered or things to be done. These formal elements include documentation, distribution, organization and project selection. The informal factors are concerned with things which are not clearly identifiable or precisely manageable. "Managerial ineffectiveness in the informal areas can negate positive effectiveness in the formal areas." (Creighton, Jolly, Buckles, 1985, p. 68) These informal elements include capacity, linking, credibility, reward and willingness. Figure 6 depicts the Information Linker Model as developed by Creighton and Jolly. The following explanation of the model factors viewed as influencing the transfer of knowledge from supplier to receiver are excerpted from Jolly (1980) and others where noted.

Method of Information Documentation refers to the format, language, report complexity and the documentation system.

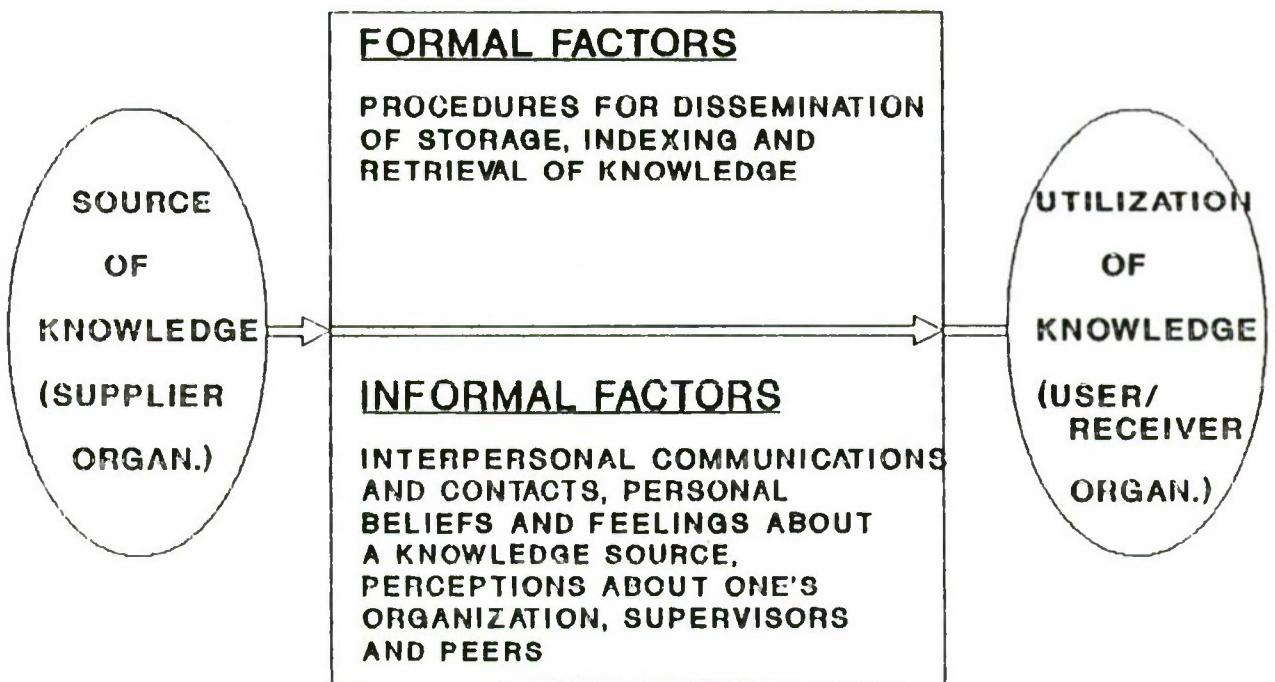


Figure 5. Knowledge Flow Enhancement Factors
Divided According to Formal vs. Informal

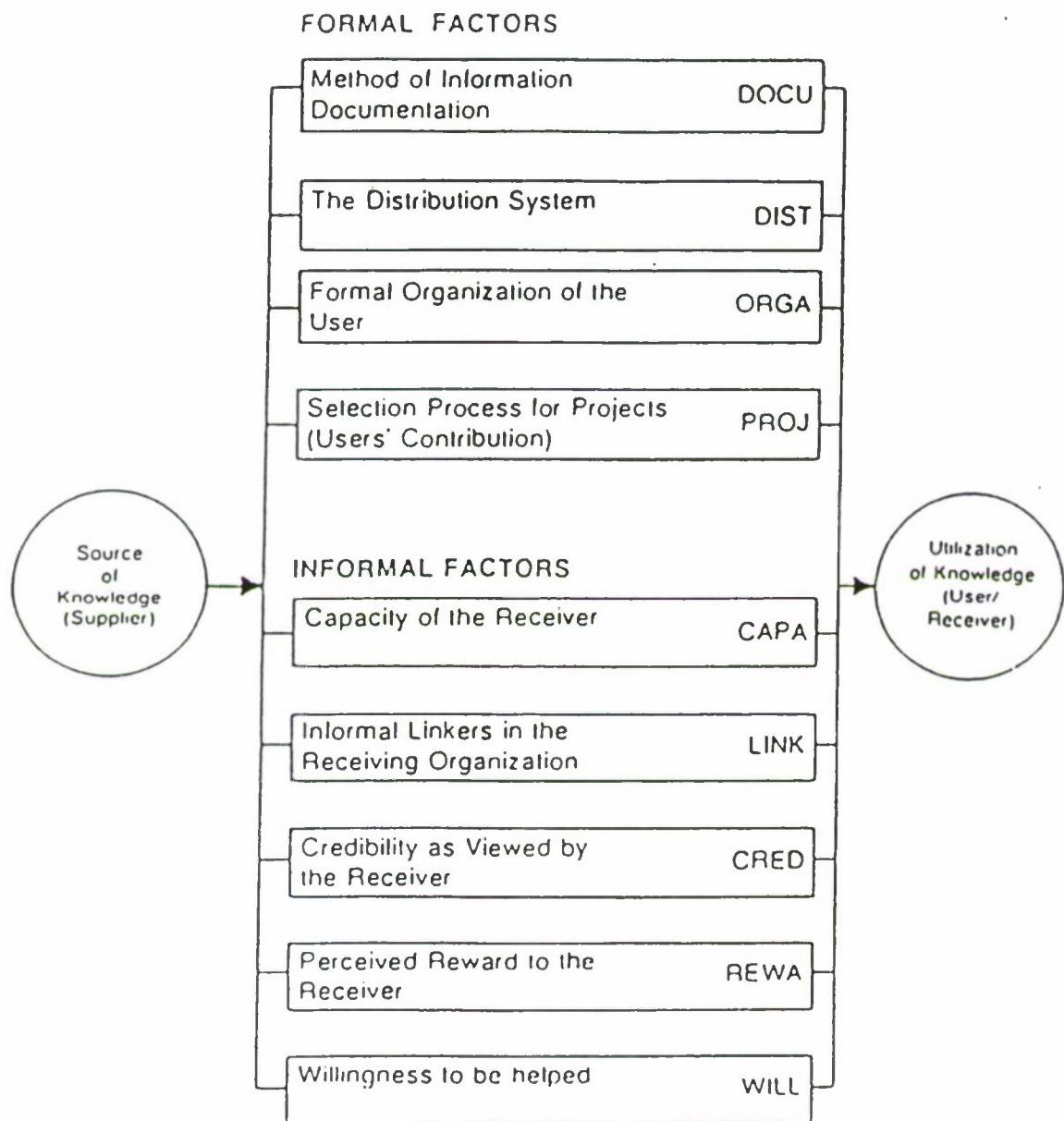


Figure 6. A Model of Technology Transfer
(Jolly, 1980)

Documentation forms include reports, technical notes, drawings, news articles, video tapes, movies, etc. Language, timing, the ability to express and awareness of the understanding level of the potential user are of primary importance. Effective documentation is of a form that can enhance the ease of movement of the technology to another person or organization. Documentation for technology transfer purposes should be understandable by users other than other researchers and developers. The form of documentation should be identified with a specific user or application in mind whenever possible. If the documentation of information is made in the language of the potential users, the later utilization of that information might be greatly facilitated.

One problem that opponents of rapid prototyping routinely make reference to is the lack of "documentation" in the form that traditional bureaucrats have been brought up to expect. All of the rules have been violated. Documentation was not complete before the system hit the fleet. MILSPECs (military specifications) were ignored in favor of documentation that was useable and understandable to the operators. Complying to MILSPEC requirements was not really practical with things moving so quickly. Before the MILSPEC review could be accomplished, the system would again be upgraded and the process would start all over again with the prior documentation effort being wasted.

Documentation is necessary, but compliance with the MILSPEC is all but an impossible requirement with rapid response to state of the art advances in computer technology. As long as the user's manual and function descriptions are understandable and readable so that the operators can use them, the current need for documentation is fulfilled. If the system is ever stabilized, then it is likely that some MILSPEC documents could be prepared, but not until then. And with the rapid advance in computers, that stabilization will not likely occur in the foreseeable future.

The Distribution system deals with the physical channels used to distribute information (Essoglou, 1975). Primary distribution systems include person to person, journals, mail, meetings, conferences and workshops. Distribution could be oral or visual as an individual sees a tape and hears its message. Distribution is verbal when people engage in conversation or when a message is conveyed during a conference. The movement of people, such as reassignment, job switching or intragovernmental transfer constitute a form of information distribution, as well (Carter, 1974, cjb).

In such a user interactive and oriented system, much distribution of information is through verbal channels as operators and developers repeatedly engage in one-to-one conversations/discussions. Verbal information distribution, a rare event during the development of most systems, is a primary distribution mode for JOTS. The continual

reassignment and inevitable rotation of personnel in the Navy provides another form of distribution as informed operators move on to become an information source at their new duty assignment.

Characteristics of formal organizations impacting on information transfer include structure, managerial climate and style, make-up of the work force, policies, the nature of the business, resources, attitudes and the state of equilibrium. "The stable state as applied to organization, is the enemy of adoptive change." (Schon, 1967) All aspects of an organization which influence productivity and the adoption of change are of concern when considering the movement of new technologies into use. "The entire field of organization study, organization development and management is vitally important in the enhancement of the use of technology." (Creighton, Jolly, Buckles, 1985, p. 70) These organizational issues will be further discussed in the following sections.

Project selection concerns procedures for selection, standards for approval, response to potential user need and assignment of resources. Project selection is very critical in the ultimate utilization of research since one tends to utilize what one has helped to develop. (Essoglou, 1975)

The entire JOTS concept was conceived due to a felt need for better C3I within the Navy. Not only are the users the reason for the program, but rapid prototyping ensures the operators a continued forum for contribution throughout the

life cycle of the system. Project selection, in this case, was an easy decision to make.

Capacity refers to the ability and capability of involved persons and organizations, both source and user, to utilize innovative ideas which might influence the movement of information. Three aspects of capacity to consider are skills, education and traits. Obviously, if a person does not understand the technical language of a research project, he cannot interpret it into use. Relevant traits include venturesomeness, power, experience, self-confidence, etc. These characteristics are vague and difficult to translate for analysis purposes, yet they are very important in the transfer process.

The developer's technicians have proven their abilities and capabilities in their areas of expertise--mathematics, computer science, programming, etc.--and are nearly uniformly on a technical level of great capacity. The operators' capacities cover a much wider range of abilities and capabilities, but could be, given time, roughly determined based on demonstrated skills and education as profiled in each sailor's service record. However, it is the opinion of this author that skills and education may not be the definitive factors in determining technical capacity. Traits such as persistence and self-confidence can override missed educational opportunities along the way. There are too many "over-achievers" to believe that education and skills can

accurately assess capacity. Traits will be further discussed in the following human factors section.

A Linker refers to an intermediary person or organization between the source of knowledge and the application of knowledge (Creighton, Jolly, Denning, 1971). An informal linker can be any individual who helps the source and the user of information communicate. The primary linker asset, the ability to communicate, includes such things as the perception of the understanding level of others, how and when to demonstrate timing and who potential users might be (Creighton, Jolly, Buckles, 1985). Without linkers there can be no success in the transfer of technology.

Credibility depends upon an assessment of reliability of information, its source, and the intermediary, by the receiver. Since individuals tend to have difficulty distinguishing between the source of origin of the message and the channel that carried the message, credibility is actually a composite of perceived reliability of both source and channel. Not so obviously, credibility also involves an assessment by the source of the ability of the receiver to understand and use the information. "In a transfer transaction, all parties are both receiver and generator of at least parts of the information which passes between them." (Creighton, Jolly, Buckles, 1985, p. 75)

Credibility of the source (the developmental contractor) is ultimately assured by the user's independent operational

test and evaluation of the system. Credibility buildup starts with initial system/intermediary exposure and continues as the developer and operator keep each other informed during the rapid prototyping process.

Rewards and penalties imposed by the management for the consequences of applying technology that is "new" to the receiving organization are crucial. A reward can be a reason for action or inaction. The perceived degree of reward, positive or negative, determines the force behind the action.

Since JOTS is a top down initiative in a military hierarchy, there is inherently some degree of reward (praise, recognition, written evaluation) placed on acceptance and implementation of the newly emerging technology. Encouraging local adaptation of new technologies, however scarce and often impractical in the military, has, in this case, been an effective means of reward. The active top-level support previously mentioned goes a long way toward forceful application of a system.

Willingness relates to the individual's ability and/or desire to accept change. Awareness is not a sufficient condition to ensure use. There must be an interest and some internal motivation to receive and implement a new method, process or device. The desire or resistance to accept and use and the degree of effort extended to transmit or respond to need are essential elements of willingness.

The user's willingness to receive the end product is cultivated and developed by involving them from the time of decision to initiate the system until the time of the final evolution of the system. Cooperation between the developer and the user fosters willingness on the part of both to transmit information needed by the other for effective design. The reward factor also has much to do with the willingness to receive.

Each of the nine formal and informal factors described plays a role in transfer of technology from source to receiver. However, it is the linker that is generally perceived as the primary factor to effect the transfer.

Essentially it is through the innovation and persistent efforts of linkers within an organization that the transfer process is achieved. Were it not for their efforts, the process would probably still occur, but at a pace more akin to diffusion. (Roland, 1982, p. 76)

D. ORGANIZATIONAL MODELS OF INNOVATION

Beyond the dominant adoption perspective, at least four notable models (Table 2) provide a more balanced picture of the innovation process. Each of the models concerns itself to some degree with the initiation and implementation phases focusing on the dynamics of the process in an organizational context.

Zaltman et al. (1973) acknowledge the importance of the nature of the innovation and the effect of its attributes on change throughout the initiation and implementation phases. This model also attempts to identify the factors affecting

TABLE 2

SUMMARY OF ORGANIZATIONAL MODELS OF THE INNOVATION PROCESS

Stage	Zaltman, Duncan, & Holbek (1973)	Hage & Aiken (1970)	Harvey & Mills (1970)	Wilson (1966)
Initiation	1. Knowledge-awareness substage 2. Formation of attitudes toward the innovation substage 3. Decision substage	Evaluation Issue perception, formation of goals, search	Issue perception, formation of the change, proposing of change	Conception of the change
Implementation	1. Initial implementation substage 2. Continued-sustained implementation substage	Implementation	Choice of solution	Adoption and implementation
		Routinization	Redefinition	

resistance to innovation at each stage. At the knowledge-awareness stage, such attributes as communication and ease of dissemination are of central importance with the issue of stability being the major source of resistance. Risk and uncertainty dominate the attitude-formation substage; financial cost is of most concern in the decision substage; and interpersonal relationships are the most important attributes affecting change in the initial-implementation substage. In the sustained-implementation substage, modifiability of the innovation dominates attributes with disillusionment produced by false expectations as the major resistance determinant. Zaltman et al., also hypothesized that a high degree of formalization within an organization may inhibit initiation of innovation yet facilitate implementation.

Hage and Aiken's model (1970) also emphasizes initiation and implementation equally and regards structural characteristics of organizations as important factors in the attainment of change. However, this model does not specify organizational characteristic influences or social and psychological variables involved. The Harvey and Mill's model (1970) focuses primarily on the initiation stage. Identification of what requires a response, how the organization should respond and determination of possible actions the organization might take are stressed. Wilson (1966) discusses the greater potential for conflict and need

for bargaining at the implementation stage because of the impact the implementation may have on different groups or units within an organization. It contends that it is easier to initiate innovation than to implement it.

All four models are speculative due to the scarcity of systematic research verifiable by experience or experiment. Yet, together, they capture the multi-faceted nature of change in organizations and serve as a framework for investigating the prominent factors operating in organizational change.

Downs and Mohr (1976) assert that while information leading to the sequence of events leading to adoption is useful, it is more desirable to examine the processes that operate when an innovation effectively replaces an old approach. Berman and McLaughlin (1974) concluded that the most difficult and complex aspect of the problem of innovation is postadoptive behavior, specifically the implementation process.

Sheposh et al. (1983) in an DPRDC study developed a schematic overview of the relationship of factors affecting the implementation process based on three perspectives as seen to predominate in the literature. The Radnor et al. (1970) perspective is that of a model in terms of a series of connecting propositions consisting of a set of independent and dependent variables identified as significant to the implementation process. Table 3 (Radnor et al., 1970, p. 974) presents these propositions. A distinct feature of this model

TABLE 3

LINKED PROPOSITIONS COMPRISING THE RADNOR, RUBENSTEIN
AND TANSIK IMPLEMENTATION MODEL

Proposition	Independent Variables Determining	Dependent Variables
I.	2. Client willingness to support implementation 3. Availability of money and personnel for implementation 4. Client's ability to perform any necessary new tasks	1. Level of implementation of the project
II.	5. Client willingness to change ongoing work patterns (if necessary for implementation) 6. Client's perception of project results, costs, benefits, and threats 7. Top-management support of the project and of the project's entire context	2. Client willingness to support implementation
III.	7. Top-management support of the project and of the project's entire context 8. Organizational and external environmental conditions	3. Availability of money and personnel for implementation
IV.	8. Organizational and external environmental conditions 9. Top-management system of variables 10. Relevant past outcomes 24. Project characteristics in the context of the researcher's project portfolio (in terms of technical, organizational, and temporal aspects)	7. Top-management support of the project and of the project's entire context
V.	11. Project characteristics in the context of the researcher's project portfolio (in terms of technical, organizational, and temporal aspects) 12. Perceived relevance (or congruence) of the project with the client's perceived needs (in terms of technical, organizational, and temporal aspects) 13. Client involvement in preproject conditions 14. Client's orientation and goals, his attitude and confidence in the research techniques, and his perception of self-interest. Includes risk aversion and perception of reward cost structure	6. Client perception of project results, costs, benefits, and threats
VI.	13. Client involvement in preproject conditions 14. Client's orientation and goals, his attitude and confidence in the research techniques, and his perception of self-interest. Includes risk aversion and perception of reward cost structure 25. Client's perception of self-interest	5. Client willingness to change ongoing work patterns if necessary for implementation
VII.	11. Project characteristics in the context of the researcher's project portfolio (in terms of technical, organizational, and temporal aspects) 15. Recognition of a "need" by the client (in terms of technical, organizational, and temporal aspects)	12. Perceived relevance (or congruence) of the project

TABLE 3 (CONTINUED)

VIII.	17. Researcher's perception of client's needs (in terms of technical, organizational, and temporal aspects) 18. Level of researcher's abilities, both technical and organizational 19. Researcher's orientation and goals 20. Client behavior with respect to the project 21. Researcher's perception of self-interest 22. Researcher's willingness to satisfy the client's needs	11. Project characteristics in the context of the researcher's project portfolio (in terms of technical, organizational, and temporal aspects)
IX.	9. Level of client's abilities 10. Client's orientation and goals, his attitude and confidence in the research techniques, and his perception of self-interest. Includes risk aversion and perception of reward cost structure 21. Client's actual needs 22. Client-researcher interaction (degree of mutual involvement, use of liaison agents)	12. Recognition of a "need" by the client (in terms of technical, organizational, and temporal aspects)
X.	8. Organizational and external environmental conditions 13. Recognition of a "need" by the client (in terms of technical, organizational, and temporal aspects)	20. Client behavior with respect to the project
XI.	18. Level of researcher's abilities, both technical and organizational 19. Researcher's orientation and goals 21. Client's actual needs 22. Client-researcher interaction (degree of mutual involvement, use of liaison agents)	17. Researcher's perception of client's needs (in terms of technical, organizational, and temporal aspects)
XII.	8. Organizational and external environmental conditions 19. Client's orientation and goals, his attitude and confidence in the research techniques, and his perception of self-interest. Includes risk aversion and perception of reward cost structure 19. Researcher's orientation and goals 23. Preexisting relations of trust and confidence between client and researcher	22. Client-researcher interaction (degree of mutual involvement, use of liaison agents)
XIII.	10. Client's orientation and goals, his attitude and confidence in the research techniques, and his perception of self-interest. Includes risk aversion and perception of reward cost structure 16. History of client-researcher interaction 19. Researcher's orientation and goals 22. Client-researcher interaction (degree of mutual involvement, use of liaison agents)	23. Preexisting relations of trust and confidence between client and researcher

is that certain dependent variables become independent variables in follow-on propositions. The interlinking propositions characterize the complexities of the interrelationships of variables that exist when an organization is undergoing change.

A different perspective by Pierce and Delbecq (1977) presents factors influencing the implementation process in terms of three basic components: organizational structure, context, and members' attributes. Major structural variables include differentiation, professionalism, decentralization and formalization. Contextual properties include environmental uncertainty, size, age and interorganizational dependence. Organizational members' attributes include job satisfaction, job involvement, intrinsic motivation and values. "Pierce and Delbecq maintain that each of these variables is independently related to organizational innovation and, in varying combinations, will influence the phases of initiation, adoption, and implementation." (NPRDC, 1983, p. 14)

Bennis (1969) offers a third perspective, i.e., viewing implementation in terms of overcoming resistance to change. This perspective, emphasizing the interpersonal aspect of the implementation process, includes interpersonal competence of managers, team management, reduction of inter and intra group tension through increased understanding, reduction in conflict through problem solving, mutual trust, client understanding and reinforcement of top management. This perspective focuses

on the implementation process as primarily an exercise in persuasion. These perspectives, in varying degrees, acknowledge the importance of structural, contextual, process and intrapersonal variables.

The NPRDC schematic overview (Figure 7) attempts to convey the complex interactive nature of the various factors in the process of implementation of innovation. The variables are viewed as complementing and reinforcing each other as they influence and are influenced by such organizational process factors as managerial control systems and the nature of communication. The organization is represented as an open, dynamic system characterized by feedback during the implementation process.

Whether proposed changes are unilaterally imposed, a product of a joint decision, or a response to local or widespread problems, the complex realities of the organization intrude and, in many instances, limit the scope of the intended implementation effort....In order for an implementation program to be successful, it must be sensitive not only to the potential sources of active resistance but also to the overall pattern of organizational systems and practices. (NPRDC, 1983, pp. 8,10)

E. MANAGEMENT'S ROLE IN INNOVATION

There appears to be a consensus of opinion regarding the importance of the involvement of top management in the innovation process. According to March and Simon (1958), top management fosters the institutionalization of innovation, determines the mechanisms of communication and coordination and sets the time period for the completion of the innovation. Sheppard (1967) views top management's involvement as

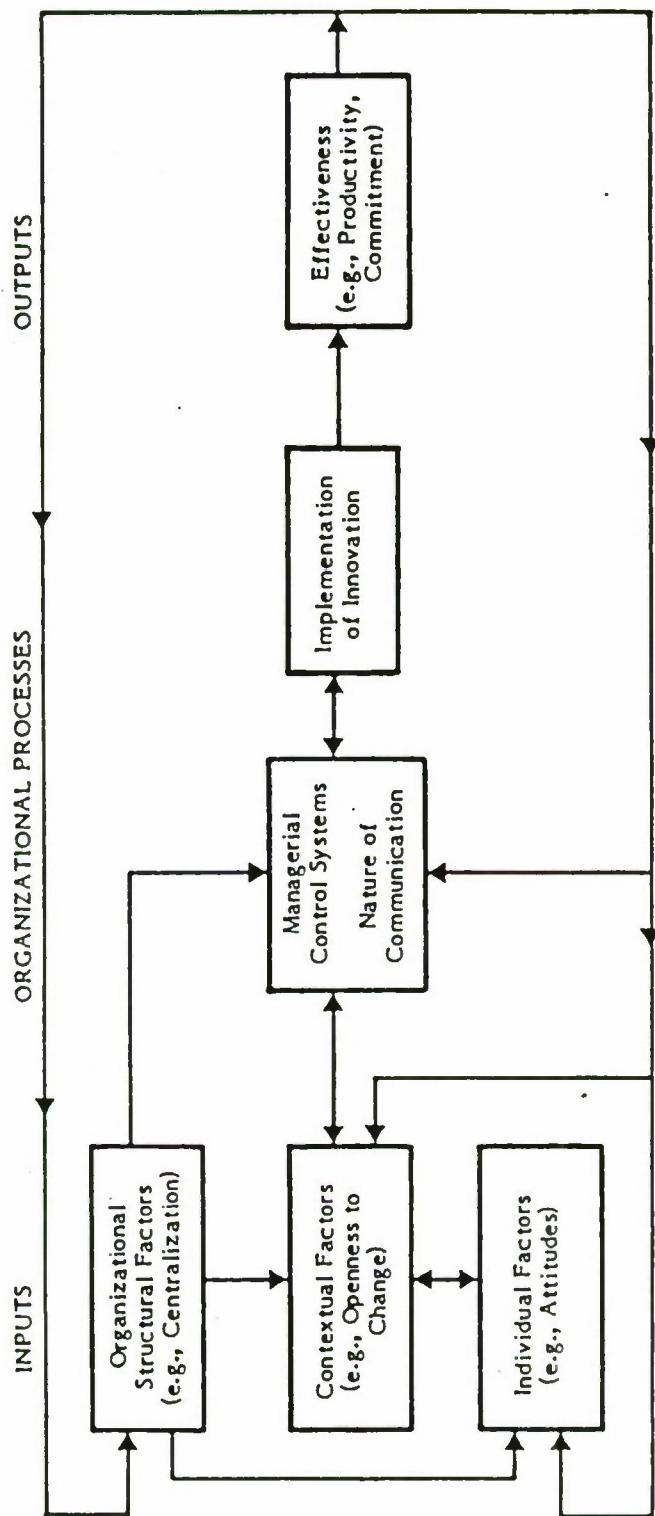


Figure 7. Schematic Overview of the Relationship of Structural, Contextual and Individual Factors Affecting the Implementation Process

necessary to overcome subunit's resistance to change that results from a disturbance in the organization's distribution of power. Radnor et al. (1970) indicate that top management support facilitates the availability of resources needed to implement new technology.

The responsibility of management does not end with the decision to adopt a new program.

It is management that is in the best position to anticipate problems and to set forces in motion to minimize or overcome them. It is management's responsibility to develop an overall strategy for change. (Gross et al., 1971, p. 212)

The role of management in implementation is seen by some as primarily that of a change agent. Managers need to sharpen their skills at diagnosing resistance to change and selecting appropriate methods for overcoming it (Kotter and Schlesinger, 1979).

Lee (1977) contends that power, leader opportunity and the ability to influence behavior, is a concept of management's role in change involved in all change models, regardless of their theoretical foundation. Indeed, top-level support was a key element of success in the rapid prototyping of JOTS to be further discussed in Chapter IV.

However, it is not likely that the importance of management is limited to the top strata. In many organizations, middle managers, much more than top managers or supervisors, have responsibility for the organizational systems and practices identified as critical to the potency

and persistence of changes realized in the workplace. The middle manager is most likely to be in a position to alter control systems in order to initiate a change in work technology (Oldham and Hackman, 1980, p. 275). Silverzweig and Allen (1976) include insufficient attention given to middle management among a list of factors contributing to the failure of organizational change. Student (1978) views the implementation of change as

Management's crucial task in the years head.... Unfortunately, few managers possess the essential operating skills to implement change effectively. In the area of planned change, managers are surprisingly adept, and too often failures are explained away as resistance to change. (p. 28)

There is also much literature concerning management practices that may be employed to enhance the implementation of an innovation. Student (1978) identifies the five factors that are essential in successful change programs as:

- (1) influence.
- (2) familiarity.
- (3) testing.
- (4) stress.
- (5) chance.

A precondition of effective influence on the receptivity of subordinates by managers is the idea that every person effected by a change can contribute to its effective implementation. Thus, a clearer definition of the objectives and a stronger sense of responsibility for successful implementation are gained. Alternatively, if subordinates

interpret influence attempts as manipulative and arbitrary, they may offer resistance no matter how appealing the change may be.

Familiarity emphasizes the importance of time as an element of successful change. Mere exposure, the degree of contact an individual has with the new object or concept, can increase an individual's attractiveness to that object and enhance the likelihood of acceptance (Zajonc, 1968). Participants may test the predictability and stability of a proposed change. This time to evaluate and test a change is essential even when very similar changes have already proven successful elsewhere (NPRDC, 1983, p. 20).

The extent to which behavioral change is required for adoption of the innovation determines the degree of both individual and organizational stress. Citing Student, Sheposh et al., contend that the change process must be sufficiently slow and controlled to keep stress within acceptable limits. And the organization must have the resources available to limit stress by support, counseling and shielding as well as by slowing the change process. (Student, 1978, p. 33) Including chance as a factor of successful change programs acknowledges that no model can fully explain the process of change (Student, 1978, p. 33).

Several investigators have recommended more substantial guidelines to manage change. Bellone and Darling (1980) recommend disseminating information concerning the innovation

to middle management followed by appropriate training activities provision of systematic participation of key management personnel as strategies for designing and implementing an innovation. Gross et al. (1970) suggest the following guidelines for the management of change:

- (1) making the innovation clear to the staff members involved in the implementation.
- (2) providing the training experiences required so that the staff will possess the capabilities needed to perform in accordance with the innovation.
- (3) ensuring that the staff is willing to make the appropriate innovative efforts.
- (4) making the necessary materials and equipment available for implementation of the innovation.
- (5) rearranging prevailing organizational arrangements that are incompatible with the innovation. (Gross et al., 1971, p. 214)

Berman and McLaughlin (1978) identified an overall effective strategy as one that supports mutual adaptation as a project is adapted to the reality of the operational setting to include:

- (1) concrete and ongoing training.
- (2) availability of local resource personnel providing practical advice "on call."
- (3) observation of the project in other organizations.
- (4) regular project meetings focusing on practical problems not administrative and routine matters.

Other recommended strategies for managing implementation emphasize personal benefits of the innovation (Schultz and Slevin, 1976) and creating pockets of commitment (Quinn, 1977). Whatever the strategy, "sophisticated behavior-

oriented techniques are bound to fail if one does not first concurrently improve the nuts and bolts of the management process." (Brightford, 1975, p. 13) The mutual influence between research and management practice is certainly evident in the interlinking of implementation problems integrally involving both realms.

F. HUMAN FACTORS IN TECHNOLOGY TRANSFER

An MIT conference on the human factors in the transfer of technology lists six human factor determinants of the ability/willingness necessary for the development and utilization of technology as:

- (1) training and experience.
- (2) individual personality characteristics.
- (3) communication patterns.
- (4) organizational effects.
- (5) mission orientation.
- (6) motivation.

Although these factors are discussed separately, they are in reality interrelated, together describing those human activities which make technology transfer possible.

Since development and use of innovations depends on available knowledge, training and experience of the persons involved would logically be a critical factor. The mechanism of technology transfer being one of agents, not agencies; "of the movement of people between establishments, rather than the routing of information through formal communications systems"

lends credence to the importance of this factor (Burns). Derek Price noted that engineers tend not to write, and therefore applied technology of recent vintage is not in the literature but "in" the people. The trend toward greater specialization of technological effort and the speed of technological advance lead to the idea that it is more efficient to bring someone experienced in a given technology into an organization than to try to develop expert personnel in an organization. It is hypothesized that internal sources are more effective in generating useful technical information than sources external to a firm (Allen).

Frustration tolerance, need for achievement, and other personality traits vary between individuals. Some of these variances can be explained by family background and other conditioning socioeconomic variables. Additionally, individual personality characteristics are related to other determinants such as organizational environment (Pelz and Andrews, 1967).

Communication patterns can be a critical factor in both development and utilization of innovations. Meadows and Marquis (1967) reported that the commercial value of R&D projects initiated by customers was far greater than that of projects initiated within R&D. Cited by Gruber and Marquis, Cochrane (1967) stated that firms where non-R&D managers were more involved with the control of R&D were rated as having more effective R&D efforts (more transfer of technology into

utilization) than firms where more of the control of R&D was maintained by R&D personnel. Communication within a firm and to the external environment was found to have been a critical factor when differences in performance were identified.

Research by Jewkes et al. (1958), Hamberg (1966) and others indicates that major innovations rarely occur in the large firms that serve an industry and most frequently are a result of activity from sources other than the industry most involved with the application of the innovation. Several theories attempt to explain this phenomenon. Notably, once an activity has become established with a given pattern, the response of the power structure in an organization is to resist change by rejecting innovations that would alter the existing activities. Secondly, organizations acting in a given way have a vested interest in maintaining the status quo, especially if an innovation may make some aspect of the organizations effort obsolete.

When demand creates an awareness of a need for new technology, that appears to be a major factor in the discovery and utilization of new technology. (Gruber and Marquis) A recognized need that leads to active search or inventive activity appears to be a critical determinant of technological advance.

The internal structures within DoD that provide systems development services attempt to link technical resources, financial consideration and perceived capabilities to meet

perceived military needs (a proxy for the market demand of private industry). This mission-oriented systems development program increases the probability of design conceptualization because demand and technical factors are considered simultaneously.

Motivation as a force may be divided into the four facets of competition, reward structure, visibility of results and government regulation. Competition serves to increase the awareness of customer requirements that leads to demand recognition and the ability/willingness to achieve the utilization of new technology. Reward structure is a motivational factor when organizations or individuals do that for which they are rewarded. The reward structure may not be designed to encourage demand recognition or willingness to take those risks which may be necessary in order to achieve utilization. Low visibility of results tends to reduce the level of motivation. "Government regulation often motivates organizations to respond in a given way, and this has an effect on whether there will be demand recognition and the ability/willingness to achieve the utilization of technology." (Gruber and Marquis, 1966, p. 273). All four facets of motivation determinants have positive and negative values with interrelationships among the factors in many situations.

G. GENERAL REVIEW SUMMARY

The implementation of change is carried out through a process which is generally recognized as having three distinct

phases: initiation, implementation and institutionalization. These stages encompass all actions beginning with awareness of a need for improvement or awareness of an available innovation through sustenance of that innovation within an organization.

Various models have been developed focusing on different phases diffusion, adoption, and acceptance of innovations. The terms used to describe the flow of the innovation acceptance process vary but follow the general pattern of: awareness, interest, trial, evaluation, adoption and support.

Some factors shown to be factors in the rate of adoption include:

- (1) proven quality and value of the innovation.
- (2) extent of readily demonstrable effects.
- (3) accessibility of information about the innovation.
- (4) cost.

Effective change strategies must deal adequately with:

- (1) planning for intended change.
- (2) establishing suitable patterns of communication.
- (3) ensuring appropriate methods of information dissemination.
- (4) optimizing quantity and quality of available information.
- (5) inter and intra group tension.
- (6) overcoming resistance to change.

Mechanisms to promote change include:

- (1) active change agents or knowledge linkers.
- (2) subordinate participation in change decisions.
- (3) continued reinforcement of top management.
- (4) reward/penalty system that tolerates failure due to innovativeness.

In varying degrees, innovation models acknowledge the importance of structural, contextual, procedural and intrapersonal variables. These complex realities of organizations inevitable intrude on implementation of an innovation and may promote or discourage the change process regardless of the innovation's independent merit. Management, at all levels, can play a significant role in promoting a desired change attempt through:

- (1) actively applying effective influence.
- (2) increasing innovation familiarity.
- (3) increasing user test opportunity.
- (4) limiting stress associated with adoption of change through support, counseling, etc.
- (5) implementing sufficient training at all levels.
- (6) ensuring availability of on-going training and on-call advice.

Just as the organization to which an innovation is being introduced plays a role in the eventual adoption or rejection of that innovation, so do the individuals within the organization. Human factors, therefore, must also be taken into account in the ability/willingness to transfer technology within organizations. Consideration should be given to:

- (1) individual training and experience.
- (2) personality characteristics.
- (3) communication patterns.
- (4) effects on the overall organization.
- (5) mission orientation.
- (6) motivation.

Considering all factors influencing change and innovation adoption including all facets of individual and organization interaction throughout the initiation, implementation, and institutionalization of an innovation will inevitably contribute to the success of that change effort.

H. NAVY SPECIFICS

Technology transfer cannot be considered in isolation from the organization in which it occurs. Technology transfer is the dependent variable, and the process through which the organizational culture develops is the independent variable. This process plays a central role in the adoption of new technologies. An organization's acculturation process is that which creates a mindset for the employees regarding what the organization really does and what is and is not important to that organization. This process occurs each time someone enters an organization, switches jobs within an organization (headquarters to/from field), or advances in grade or rank.

When dealing with the issue of how the Navy acculturation process relates to technology transfer and the management of change, it is important to keep in mind that there are two

sets of managers, civilian and military, with different orientations that enter into the transition process. Proceedings of a 1986 NPRDC/ONR (1986) workshop on improving the research transition process include a profile of both civilian and military managers as provided by Dr. Tweeddale, technical director of NPRDC. Accordingly, the military manager has a strong orientation to the fleet and the chain of command, goals constrained by tour length, centrally directed mobility and motivation directed at achieving promotion through good fitness reports. The civilian manager has strong orientation to the local activity or career field, goals coinciding with personal interest, self-directed mobility and motivation toward growth opportunities within a "keep what you have" orientation. Military decision processes are often perceived by civilians as dysfunctional and incremental. Faced with needs for rapid career progression, military managers often perceive civilian decision processes to be slow and parochial. Military managers view themselves as having ownership of command decision responsibility and as being the controlling official of the organization. Civilian managers, conversely, view themselves as a staff resource.

It is clear from this differential profile that each group must play a different role in the introduction of change. In order to transition research and development into an organization, there must be acceptance that change is necessary, the R&D solution is the correct option and the

resources and support are available to institutionalize the change. Dr. Tweeddale contrasts the differing responsibilities of the military and civilian managers in the acceptance of change as follows. Civilian managers have primary responsibility in ensuring that the change is directed to an existing and recognized problem and assessing the quality of the information on which the change is being based. Likewise, the civilian manager must look at the technical maturity of the new method and the extent to which the chosen alternative has been tested and evaluated before delivery. Military managers have the responsibility for establishing the availability of resources to implement change within the budget framework. Creating a climate that supports change, reasonable risk, and encourages individuals to identify with the organizational goals is the responsibility of both military and civilian managers.

To some extent, all of the change factors are probably the responsibility of both sets of managers. However, ... each group has predominate responsibilities for different segments of the change process. (NPRDC, 1986, p. 10)

Being aware of their organization's acculturation process enables managers to keep in mind what is going on at all levels of their organization, especially at the bottom where most newly acquired talent that the organization depends on is actually employed. Otherwise smart, honest, and hard working senior management may become preoccupied with day-to-day issues and add to an accultured inactivity through which acceptance of nonchange is perpetuated. The value system of

these senior people may determine whether their organization has an inclination toward change and a tolerance for error, both of which are important to technology transfer. Awareness of their culture determining practices should make it possible to choose more effectively what to encourage and what to deemphasize in order to foster an organizational acculturation supporting adaptation.

The issues of technology transfer, probably more succinctly than any other issue, are a yardstick for the quality of an organization's management. Organizations that demonstrate an ability to systematically direct new technology at targets of opportunity have understood the social forces that counter innovation and gained control over them. (NPRDC, 1986, p. 12)

Technology transfer occurs through the interaction of the characteristics of the new technology with the characteristics of the organization. Within the DoD environment, acceptance of change is complicated by the existence of the dual culture discussed. Managers promoting cultures that seek improved technologies and support their implementation will surely maximize the benefits to be derived from research (NPRDC, 1986).

Some Navy personnel are of the opinion that transition is only important if it ultimately serves the Navy in its primary mission. In that vein, the focus should be on whether operational problems are being served rather than whether R&D products are being transitioned.

Dr. Kent Crawford, in the conclusion of the NPRDC/ONR workshop previously mentioned, suggests ten ways in which the

Navy can begin to systematically improve the research transition process. There is a need to:

- (1) Develop a clearer definition as to what constitutes successful transition and when transition is indeed necessary.
- (2) Develop a framework linking mature technologies of the behavioral sciences with targets of opportunity in the operational forces. This need to integrate the most relevant dimensions of behavioral theories and apply them to current Navy problems may involve better methods of communication with the fleet and "selling" the benefits of behavioral science that are available.
- (3) Systematically evaluate new technologies after implementation. Failure to maximize the usefulness of a newly implemented technology could result from complex interaction of the characteristics of technology and the organization.
- (4) Assess the extent to which the current R&D system rewards researchers who successfully transition their efforts. The R&D system's rewards seem more directed toward achieving research objectives than transition objectives.
- (5) Improve communication between the researchers and the users, especially how well user problems and views are translated to the researcher. Likewise, the users must understand the researcher's need to retain a certain degree of objectivity and creativity so that constructive innovation is fostered.
- (6) Examine whether different methods of conducting Navy R&D may create user relevant knowledge as opposed to scientifically relevant knowledge thereby resulting in more successful transition.
- (7) Develop a better bridge between private sector academics and the Navy applied research community in order to foster creativity and help direct private sector expertise to Navy problems.
- (8) Encourage more communication between the research managers and sponsors of ONR basic research and exploratory development and their counterparts in the OPNAV advanced development, engineering and test and evaluation community. Two different reporting chains increases the potential for poor communication between these critical research elements.

- (9) Assess whether the structure surrounding R&D management in the Navy contains the formal links necessary to promote and support transition of mature technologies.
- (10) Given that the aim of Navy labs is a technology base that is both useful and used, as opposed to research for the sake of academia alone, there is a need to learn more about the when, where, and why of the successful transition process. (NPRDC, 1986, pp. 109-111)

In general, the acceptance of JOTS as a new device and a new technology can be viewed as a special case of the broad problem of implementation of change, innovation acceptance, technology transfer, etc. The next chapter provides a background of the rapid prototyping of JOTS as a case study of successful innovation implementation.

III. CASE STUDY BACKGROUND

Inter-National Research Institute (INRI) developed the Joint Operational Tactical System (JOTS) with primary emphasis on battle management. Battle management is the total process comprising the methodologies, tools, and processes or procedures used by Battle Group Commanders or other force commanders to permit the force to successfully respond to whatever the current roles and missions might be. INRI views improvements in battle management as being attainable only through:

- (1) rapid development of new computer systems.
- (2) immediate adaptation of programs to new computers as they are developed (i.e., translation to appropriate operating systems and languages).
- (3) centralized management of the C3 computer systems to attain configuration control and standardization. (INRI, 1987b)

It is essential to understand the background of the developer of JOTS as well as a brief history of JOTS itself in order to appreciate the significance of its innovation implementation process. Analysis of these areas reveals some significant factors facilitating this rapid prototyping success story.

A. INRI HISTORY

The Inter-National Research Institute was incorporated in 1966 in McLean, Virginia. As a management consulting

organization, the firm initially offered its services and performed work for the U.S. Department of Defense and associated defense corporations. Throughout the 1970's, the firm's scope of activities broadened from its original base of defense systems analysis and operations research to include a wider range of management including economic and fiscal services both domestically and internationally.

INRI has provided its consulting services to defense companies; industrial concerns; federal, state, and local governments; and government and business concerns in foreign, particularly developing, nations. Specifically, it has been qualified to and interested in assisting U.S. organizations in improving their relative efficiency and developing countries in furthering their industrialization and economic growth. In order to accomplish such goals, the company has been prepared to perform both research and consultant work by the application of disciplines and the use of knowledge in such areas as systems analysis, operations research, logistics, manpower and personnel, economics, international finance and banking and engineering. (INRI, 1970)

INRI's McLean office has historically served program managers and branches of OPNAV in the areas of defense systems acquisition, systems integration, cost imposing strategies, strategic defense initiatives and trans-atmospheric vehicles. INRI's Battle Management Sciences Division was initiated in Newport News, Virginia in May 1984 and expanded to San Diego,

California in October 1985 with a field office established in Honolulu, Hawaii in 1987.

The Newport News and San Diego offices are technical and operational in nature, doing most of their work in the areas of computer tactical decision aid systems and tactical development. The personnel in these offices possess backgrounds in mathematics (mostly Ph.D.), computer science, teaching, and operational experience with deployed Naval forces. As a group they have deployed in 50 plus Naval ships in the process of evolving complex tactical decision aid systems. These computer systems support Battle Group Commanders, shore operational control (OPCON) centers, frigate anti-submarine warfare (ASW) teams and other specialized activities.

These Battle Management Systems are being integrated by INRI with many embedded systems such as tactical flag command center (TFCC) and AEGIS, and the concepts are being factored into the evolution of other systems such as ACDS and SUBACS. Specific project work to date includes:

- (1) development of computer tactical decision aid systems for use by Battle Group Commanders including evaluation, training, systems design, software architecture, programming and analysis.
- (2) determining systems design, architecture, and algorithms for Naval decision systems to be produced over the next ten years.
- (3) development of an interactive graphic/analysis system to support planning and execution of Naval missile shots and manned raids.

- (4) development and exercise of a major simulation to determine the systems requirements for the next generation submarine sensors.
- (5) development and evaluation of tracking techniques to support long range cruise missile weapon attacks on ship or land targets.
- (6) planning of optimal asset employment to achieve threshold goals in the areas of anti-submarine and anti-air warfare. (INRI, 1988)

An exhaustive list of INRI corporate contract experiences would be overwhelming. However, those project areas mentioned above are sufficient to recognize that the bulk of the workload in the 1980's has largely paralleled significant advancements in leading-edge computer technologies.

B. JOTS EVOLUTION

The history of computers as battle management tools through tactical decision aids (TDA) began in the not too distant past. In the early 1970's, there was some cautious use of computers to test their use as planning aids. By 1977, there was enough evidence of potential to establish model managers at the fleet level. The funding was modest, in the hundreds of thousands. The objective was to develop special purpose TDAs mostly as not-to-interfere experimental models. With no real support after development, this effort became an unsuccessful attempt to evolve into a program. (INRI, 1984)

Before the advent of desk-top computers in 1975, the only computer-based tactical decision aids operational in the Fleet were those associated with or embedded in specific sensor or weapon systems, those comprising Naval Tactical Data System

(NTDS) and a few hand-held targeting aids developed for the submarine force in the early 1970's. The AEGIS weapon system promised a better integration of computers with battle functions within the individual unit, but it was not afloat in 1975 and even by 1985 not fully integrated with the Battle Group.

In the submarine force, from the early 1970's, slow hand-held computers assisted in targeting, and in some laboratories large scale computers handled advanced problems with no means of transporting their capabilities to the fleet. At the same time, new and proposed weapon systems (U.S. and Soviet) were forcing better means of coordinating naval assets and providing faster and better solutions to important tactical problems. The introduction of powerful desktop computers showed promise for full integration with existing computer systems and provided a means for developing dynamic computer support for Battle Management.

Software to support decision making by the Battle Group Commander was at first developed unsystematically with the various activities arranging for the aids they needed on an individual basis. Operational commanders could look forward to a long developmental cycle prior to approval of tactical decision aids under normal procedures. In the meantime, rapid advances in the art of warfare forced an examination of new technologies for tactical applications. There was a need for single function aids operating off-line and discrete from

other networked data links. In addition, there was the need for the development of multi-functional integrated aids operating with full use of external data. In a multi-mission, composite warfare environment, an ASW picture could become an anti-air warfare (AAW) picture with the firing of one submarine launched cruise missile. In an environment of shrinking battle time and expanding battle space, the commander needs a near real time picture with rapid and dynamic display and/or alternative courses of action. (INRI, 1985)

The Joint Operational Tactical System, in 1981, was a step away from the single function, single purpose aids. In this initial step towards a battle management system, useful single purpose aids were linked together crudely into a loosely related whole. The user could run selected programs but data exchange among programs was minimal. The most important deficiency was the lack of automated inputs. Despite the system's shortcomings, the aids had come together in a single system and the concept of an integrated TDA had been born.

The next stage in the development of a decision aid system was the "integration" of the database, as in JOTS II. Even though the programs still functioned as single function aids, they now allowed for the later development of more complex forms of integration, including computer generated alerts and prompts. The single function aids were being woven into a

system, and the stage was set for the real time processing of link data.

Real-time updating in an integrated tactical decision planning system was first achieved in the summer of 1984 when Link 11 data was intercepted by a link monitoring unit and fed through a front end processor directly into the database of a microcomputer. As link data fed continuously into the background of one partition, other partitions could be used for the planning functions. Such "concurrent processing" allowed for planning functions that overlayed and automatically updated the tactical picture only a few seconds older than the NTDS picture. By similar means, operational intelligence (OPINTEL) data could also be fed into the system.

In 1984, Commander Naval Air Atlantic (COMNAVAIRLANT), the chief sponsor of the system, began installing JOTS II on aircraft carriers in the Atlantic and Mediterranean generating increased interest for JOTS and JOTS-like systems. JOTS II did not include the real time capability mentioned above, but it did introduce a large screen display and a host of newly integrated programs. The computer graphics screen replaced the traditional grease pencil and a large screen display replaced the plexiglass plotting surface.

In the spring of 1985, JOTS II+ was introduced to the fleet on the USS Coral Sea. This system included integrated tactical planning, dynamic graphic interaction, and multi-terminal displays on a real time basis.

During 1986 and 1987, Commander-in-Chief Atlantic Fleet (CINCLANTFLT/CLF) initiatives demonstrated the capability of exchanging digital data among all crucial commands within the Area Of Responsibility (AOR) and of focusing data in the newly created Atlantic Fleet Data Fusion Center for CINC level battle management. This effort involved creating the Fusion Center as the focal point of the AOR, networking local automated data sources to the Fusion Center computers, placing compatible low cost systems at representative shore bases and at-sea command centers throughout the AOR, and establishing operational lines of communication among all installed systems and the Fusion Center. The result of this effort opened the way for rapid deployment of similar systems at other critical command centers both ashore and afloat.

The Joint Tactical Data System has evolved from a stand-alone off-line tactical decision aid used for planning purposes to an integrated, real-time battle system. Taking advantage of the successes of the system in Battle Group operations at sea, CINCLANTFLT sponsored the application of the JOTS concept at higher levels--the afloat Battle Force Command (USS Forrestal CV59), the afloat Numbered Fleet Command (USS Belknap CG26), and the shore-based Commander-in-Chief (Atlantic Fleet Data Fusion Center). The same system, modified to accept separately developed communications feeds has been placed at ASWOC stations (Keflavik, Iceland; Bermuda; Jacksonville, Florida), in a critical MDZL Command Center

(Miami, Florida), at the Naval War College (Newport, Rhode Island), at a NATO SOC in United Kingdom (Northwood, UK), at a coastal monitoring station (FACSFAC, Vacapes, Virginia), and at a fleet training facility (FTGLANT, Dam Neck, Virginia).

Complementing the above evolution have been many vitally critical experiments involving secure landline, satellite (UHF and SHF), and intracomputer communications necessary to provide the paths for data sharing from all available feeds including link 11, link 14, POST, FHLT ASWCCCS, OPINTEL, FOSIC, NWIS (Navy WWMCCS), NEOC, OTCIXS, TADIXS, JOTSIXS, and others. (INRI, 1987a)

The installations described above are operational. Training has been effected; maintenance training and operational retraining are in effect. And documentation is in place or in preparation. The ever-increasing number of facilities (ships, staffs and shore stations) with JOTS installed will soon have the capability of data exchange over the communications network. The focus for all data flow is the Atlantic Data Fusion Center whose functionality is the basis for other centers which together will comprise a worldwide Navy Battle Management System. The Atlantic Fleet system is being expanded and enhanced allowing advanced systems being installed in the Pacific Fleet to similarly focus at the PacFleet Fusion Center. Now JOTS, having been proven both afloat and ashore, will be extended for use throughout the AORs at each site that can be networked

including all shore based command centers, MDZL, ASWOCs, all afloat high value unit (HVU) command centers, training center locations and Navy Space Command Facilities. Further development of JOTS in the Pacific and Mediterranean will complement the Atlantic fusion design with the potential to form a Worldwide Naval Data Fusion Network in the not-too-distant future (INRI, 1986).

The development of JOTS as an Integrated Tactical Decision Aid (ITDA) was accepted by the Atlantic Fleet Carrier Battle Groups (CVBGs), not as a static and intractable system, but as a dynamic and growing system that is responsive to Fleet needs. The other services and DARPA have shown interest in the JOTS type of architecture as directly applicable to their programs.

The following highlights of the JOTS development show the rapid advances made and the major breakthroughs which permitted those advances to happen:

May 1983	JOTS I was the first integrated tactical decision aid (TDA) system for flag staffs with single purpose planning aids linked together with minimal data exchange among programs but still with no automated inputs. Five carrier staffs had JOTS installed.
May 1984	JOTS II consisted of two or three computer stations on a carrier using a common database. The database was somewhat limited; active data fed in manually but stations were still single purpose TDA's. JOTS was installed on ten ships.
July 1984	JOTS IIA was a refined and enhanced system with the addition of a large screen display and new programs. JOTS was installed on 14 ships.

August 1984 Link 11 was automatically fed into the JOTS database from a down link giving real time capability to the system.

March 1985 JOTS II+ allowed multi-terminal operations to be tied to a common display utilizing parallel processing and making TDA's interactive. JOTS was installed on 17 ships.

May 1985 OPINTEL and Link 14 inputs were added to the system with message generation and inter-computer contact exchange. JOTS was installed on 24 ships.

August 1985 JOTS established a tie to the FDDS rainform gold message system with a two way exchange. JOTS was installed on 33 ships.

January 1986 JOTS III was the first integrated computer system on a ship with a single database and fibre optic buses between computer stations and the color plotter. Inter-computer planning, alerts and a color plotter were new additions. JOTS III was installed on the USS Nimitz and Yorktown.

April 1986 JOTS IV was a networked 7 computer system installed on the USS Forrestal Battle Group with all the features to date plus intership/shore data link (IJDL) permitting data transmission via satellite among JOTS computers. JOTS was installed at Keflavik ASWOC and successfully communicated with the CLF command center at 2400 baud.

May 1986 INRI demonstrated the large screen display in the CLF command center using the new GE light valve driven by the HP9020 JOTS computer.

June 1986 The USS Belknap deployed to become the COMSIXFLT flagship as the first JOTS equipped Fleet flagship. Line-of-sight (LOS) data transfer between the USS Forrestal and MacDonough proved the concept of LOS battle coordination between ships with IJDL.

July 1986 JOTS was integrated with the Tomahawk cruise missile (Tepee), the High Interest Target (HIT) broadcast system, the Tomahawk Weapon Control System (TWS) onboard the USS Iowa, FDDS onboard the USS Nimitz, and the OTH-GOLD formatted HIT broadcast onboard the USS South Carolina.

September 1986 AWACS data stream receipt commenced at the CLF command center.

October 1986 The JOTS interface with the ASWCCS net was established with SHF communications between CLF and the ASWOCs. The JOTS interface with ON-143(V)6 initiated the JOTS Information Exchange System (JOTSIKS) for two-way tactical data exchange between JOTS installations via satellite. Secure landline data transfer was demonstrated at 2400 baud between any JOTS computers which have a Secure Telephone Unit (STU) II available.

November 1986 JOTS was installed at Northwood UK SOC as the first link to NATO. Testing was satisfactory between Northwood and CLF. JOTS was also installed at Naval War College, Rhode Island; Fleet Activity Center, FACSFAC, Vacapes; and the Bermuda ASWOC. WWMCCS was tied into the JOTS system through NWIS.

January 1987 JOTS was installed at COMNAVSPACOM.

June 1987 JOTS was installed on the USS LaSalle (COMIDEASTFOR).

July 1987 Two JOTS systems were installed at TAC-first USAF installation. JOTS deployed on both the USS Missouri BG and the USS Coral Sea BG. An installation at the JCS office tied into CLF, IJDS, and CMEF. A demonstration installation was established at USCENTCOM, Tampa, Florida.

August 1987 JOTS was installed at USCENTCOM, MacDill AFB. Four units were installed at Wallops Island NWDS, and a site survey was completed for an installation at the National Command Center (NCC) for the CNO.

September 1987 JOTS was installed at the CNO National Command Center, USSPACOM Peterson AFB, NISC and NAVSPACOM, Dahlgren, Virginia. (INRI, 1987c)

1988-1990 Much of the past three years has been devoted to replication of the system programs and continual enhancement and expansion to more ships and major command centers. The JOTS systems have been

moved to UNIX-C, transported to the SUN DTC2 computers, and installed at all major CINCS.

It is interesting to note that these advances in the warfighting capabilities of the U.S. Fleet were accomplished by a relatively small group of dedicated technical people, led by a few motivated strong-willed people using one standard desktop computer and making use of existing fleet capabilities, sensors and communication installations. Except for a large screen display which became a necessity as the program matured and some ancillary equipment needed to adapt or screen data, no new hardware was required. Yet the system has evolved from a single purpose, stand-alone tactical decision aid to a capability of a worldwide fusion system capable of transferring battle management data among all command centers, ships, and shore stations--of all services--including NATO allies.

C. BARRIERS INCURRED

The road to success in performing this contractual work for the government was not free from roadblocks, delays, nay-sayers, skeptics, and bureaucrats who, to varying degrees, dislike rapid progress not accomplished "according to the book."

Any new innovative system is likely to displace an/some old system(s)--some of which are still in the formative stages with years of very ample funding ahead. The companies who are involved in those programs are apt to feel threatened by a new

kid on the block and some managers, military and civilian alike, tend to be over protective of their programs/systems and oppose the new program. At times, this is done only to protect themselves and their people having little to do with the merit of their program. If a \$200 million program planned over the next five years can be done in as little as one or two years for \$5 million, the high priced companies are threatened. Some feel that those threatened companies have sufficient political clout to get those in favor of "the new program" discredited and cause the new program to be delayed or even dropped. Some fear, as a small company, INRI may be able to do the job faster, better and for less expenditure of funds. There seems to be great apprehension that a rapid prototyping approach may take away the big cash programs from the big companies.

It is very likely that the rapid prototyping approach will save billions of dollars, even if only considering the time saved prior to realization of an operational fleet system. But if that is so, it would put a lot of people out of work which is something Congress is not likely to be in favor of. Furthermore, it is unlikely that a significant number of contractors are both qualified and willing to do what is required to make rapid prototyping work (to be explained fully in Chapter IV). In other words, much of the slow development of military systems may be the result of political pressures, civil service fear of proliferation of systems, the desire to

put everything under MILSPEC standards and forcing everything to operate under the cumbersome PPBS system. None of the above is consistent with the rapid prototyping process.

Another problem facing the JOTS development company is the matter of company size. One of the fundamental issues of most major programs is that they are under the large corporations where layering and internal bureaucracy tend to hamper progress. The bottom line, profit, often drives the program and integration of the system does not get done. The technical expertise that brought a company to the forefront in their field may eventually be promoted to the higher-paid positions in management diluting the technical prowess with increased size. Although there are undoubtedly highly capable people within the large corporations, they are too frequently unable to do an effective job of integration. INRI is very conscious of the fact that their corporate President and Vice President must not get too bogged down in routine management lest their company lose that technical expertise for which they are currently highly regarded.

Another cause of delay in the rapid prototyping of JOTS is due to mandates on competition for successive program contracts. There is no way that the JOTS program can be expanded on a sole source basis in today's climate of competition. There is a very real risk that a less capable company may win a competition on price alone, but will not be able to do the job and the program will fail. There is a very

real possibility that the Navy's warfighting capability could be sacrificed in the name of competition. Competition did in fact slow things down as one fleet support contract initially won by INRI was overturned after a protest by a competing contractor which has since proven to be less capable. Another contract was won by an company without sufficient developmental capability and the Type Commander directly effected by that contract has suffered, in capability, ever since. That was not the fault of the type commander but was apparently the fault of the procurement system that insisted that "cheap is best."

Another barrier to rapid progress stems from the apparent scarcity of forward-looking, risk taking, positive thinkers in top ranking key positions who are willing to take on the system and disrupt the checklist oriented bureaucracy. Perhaps, in peacetime, it is possible to get ahead if one goes "by the book," avoids "rocking the boat," and takes no risks looking only far enough ahead to complete a tour of duty and move on. The author of this thesis believes that this is not merely a symptom of top ranking officers but an attitude that is perpetuated throughout the ranks. Just getting the proper "tickets punched" in order to continue to advance is a sad but accurate reality for many officers today.

There does seem to be another problem which is nearly exclusive to top level officers. It appears that at greater rank, greater merit is associated with programs of greater

dollars. Admirals are inclined to sponsor huge money programs, not relatively inexpensive programs at "a Captain's budget." Bigger is better; or is it?

Some other barriers faced by all software intensive innovations within the military were brought out in a briefing by Bud Wassgett from Combat Systems Integration and Testing (CSIT) presented to an acquisition class at Naval Postgraduate School in Fall 1989. Wassgett claims there is an inherent perception problem when it comes down to bullets versus bytes. Table 4 depicts some myths and misunderstandings that affect high level decisions concerning software. "Bottom line: Real men buy bullets...not bytes." (Wassgett, 1989)

The same presentation by CSIT highlighted a report of the Defense Science Board Task Force on Military Software.

The number of software qualified military officers has been essentially constant over the past decade, despite exponential growth in software. Many studies have recommended actions that need to be taken...the number has not increased. (Wassgett, 1989)

For the military to continue to lack officers qualified in software only serves to ensure the continued existense of authority figures who are not educated to the point that they can ask intelligent questions ensuring program status accountability of the ever increasing number of software intensive programs.

TABLE 4

BULLETS VS. BYTES

<u>Bullets (and gunpowder)</u>	<u>Bytes (and computers)</u>
* Bullets are something you bite	* S/W is composed of bytes
* Bullets and gunpowder go "bang"	* S/W is silent
* "Real men" make bullets	* Gremlins make S/W...then live in it
* Only superman can stop a speeding bullet	* Anything and everything stops software
* Bullets are immune to disease	* Software carry viruses
* Bullets go fast	* Software never goes fast enough
* Bullets are for your protection	* Software must be protected
* Bullets can kill, maim, destroy	* Software sounds like something you could lick...or should.

Source: (Wassgett, 1989)

IV. RAPID PROTOTYPING: ELEMENTS OF SUCCESS

JOTS was born in the minds of Navy's Battle Group Commanders as a warfighting system--a unified collection of tactical decision aids. Its premise is that the U.S. must constantly and immediately upgrade its warfighting capability when the need arises--when the threat capability changes, when the technological base offers new capabilities for system integration and enhancement, or when we learn a little better how to employ what we already have.

Historically JOTS served first as a sketch pad for the battle planner and his staff, as a static, off-line graphic aid. JOTS eventually grew to become a near real-time tactical system incorporating automated data through existing link and intelligence feeds whose real-time contact reports could be operated on by a host of so-called decision aid functions. (INRI, 1987b)

System development, working on the leading edge of the technology base, has been a cost-effective means of battle planning for the increasingly complex environment of contemporary warfare. Rather than first developing JOTS in a laboratory setting and then delivering it to the fleet for test and evaluation, JOTS was developed at sea in the operational environment of its intended use by continuous interaction with the end user. Rather than freezing system

capabilities at one technological level, JOTS has been designed to incorporate flexibility and growth as dictated by advances in tactics and technology.

As the Navy's multi-computer, multi-communications command and control system, JOTS integrates the battle picture at any and all levels of command in all the world's ocean areas and is utilized operationally worldwide for data fusion, transfer display and manipulation. Because it is an operational, evolutionary system, it continues to grow with the field commanders who define requirements in a rapid development mode to meet the threat. This rapid prototyping concept is a means of keeping pace with technology by marrying new innovations with system requirements. Many ingredients appear to have been essential for this successful rapid prototyping of JOTS in the fleet including:

- (1) on-going configuration management.
- (2) aggressive support of users.
- (3) advanced planning and coordination.
- (4) accelerated procurement cycle.
- (5) acceptance testing criteria/program.
- (6) a complete installation/maintenance support package.
- (7) extensive training/implementation.
- (8) life cycle support for maintenance, troubleshooting, and upgrading.

Additionally, vital to the widespread acceptance of the JOTS rapid prototyping effort in the fleet are:

- (1) top level support.
- (2) the right people to provide liaison between the developers technicians and the Navy's operators.

A. TOP-LEVEL SUPPORT

The success of today's battle management system in the fleet is due in part to the support and efforts of three principal individuals and a large number of supporters. Those individuals are Dr. Frank Engel, Dr. William Reckmeyer, and Adm. Jerry Tuttle. Dr. Engel provided the essential technical expertise. Dr. Reckmeyer provided the corporation and financial support. Admiral Tuttle provided the much-needed, strong, top level support--the importance of which cannot be overstated. Other supporters have included a long list of naval officers, from Four Star Admirals down to Commanders. The junior officers in the fleet have also been supporters, but rarely are they able to expose the virtues of JOTS to the world. Fortunately, Adm. Tuttle was and is in just that position.

JOTS got its start in 1981 when Rear Adm. Tuttle was Commander Carrier Division Eight, in his flagship USS America. As Adm. Tuttle moved up, so did JOTS: 1983, Rear Adm. Tuttle, Commander Carrier Group Two; 1986, Vice Adm. Tuttle, Deputy CINCLANTFLT; 1987, Director of J-6 (JCS) Command Control and Communications. Thanks to his efforts, JOTS became part of day-to-day operations onboard ships, in fleet headquarters,

and in the National Military Command Center. JOTS has reached the top of the DoD C3I hierarchy. (Lake, 1989)

Inside the Navy writes that JOTS may become the chief C3 system used by all services throughout the world according to Admiral Tuttle in a recent interview. "When it is suggested that JOTS could replace many different command and control systems, Admiral Tuttle replies, 'Hopefully, it replaces all'." (Inside the Navy, 1989. p. 4) Share his beliefs or not, one cannot help but admire his confidence in the system. Unwavering top level support, like that demonstrated by Admiral Tuttle for JOTS, can only help to accelerate the pace of acceptance throughout the fleet.

Like the Navy, INRI's Battle Management Division is not without its own top level support for the JOTS program. Dr. William Reckmeyer (INRI president, treasurer and chief executive officer (CEO)) provided both the corporation and the financial support. As became quite evident in an interview by the author with Dr. Reckmeyer in September 1989, however, he has contributed something beyond those tangible items. Dr. Reckmeyer provides something of perhaps even greater demand. He has established a mindset of creative, forward-looking, integration thinking. His inclination is clearly evident from the contents of the Inter-National Research Institute brochure from approximately 1970. Reckmeyer writes, "Attitudes--in the presence of facts--may well be more significant than the facts themselves" and "Technology and Management, Motivated to

Service, Working Today...For Tomorrow." (INRI, 1970, pp. 1, 9-10)

Originally, INRI was headed by Dr. Reckmeyer with everyone reporting directly to him. There was no other structure. When Dr. Frank Engel joined the company, he became manager of the Tidewater office in Newport News (now in Yorktown) and set up his organization as the Battle Management Sciences Division with himself reporting to Bill Reckmeyer. The Development Division in San Diego reports to Frank Engel. The organization is becoming more structured as a matter of necessity as the number of employees is nearing 70.

Under the old INRI structure, Reckmeyer hired mostly retired military personnel having whatever area of expertise was needed by a particular contract. Most employees then were hired as consultants and worked as necessary when there were contracts in hand. Most of those consultants eventually became full-time employees. At that time, INRI was still more or less a "think tank" of management consultants.

When Frank Engel came to the company, INRI stood at about 15 people strong. These few people were able to adequately handle the development, programming, installing, training, at-sea support, etc. In the beginning, work was concentrated on the carriers and battle group staffs and the number of installations remained limited. It was when the system was expanded to cover the subordinate commanders and then the individual units of a battle group that the burden increased.

These early employees were able to cover a lot of area as they made numerable COD and helicopter transfers jumping from ship to ship while underway to do the installing, upgrading, training and responding to trouble calls. They have transited by highline and small boat as well, since generally, a battle group has been serviced by only one person underway.

At that point, most of the basic programming for JOTS was done by Dr. Frank Engel himself. That which was done by his people was almost inevitably reviewed in detail by him personally. For new developments, that is still the case. Frank knew programming and learned tactics and battle management at sea with the staffs, admirals, and ships officers and enlisted during his development and enhancements of JOTS.

Besides those that Dr. Engel brought to the company with him, the next five or ten people came from college recruitment. They made the rounds of appropriate colleges and interviewed those approaching graduation from undergraduate or graduate studies, mostly looking for programmers, computer science graduates and mathematics doctorates. Frank looked for people with potential, people who he felt had the basic programming training, but were deemed to be learning prone and adaptable. Interview questions conceivably focused not on how much the person knew, but on how the person would approach a difficult problem in programming.

B. DEVELOPER/USER LIAISON

Any attempt to transfer technology must include a mechanism which effectively links the source of knowledge with the eventual utilization of that knowledge. A simplified view of the linking mechanism is depicted in Figure 8. The linking mechanism is not merely a series of communication channels through which information flows. It is, instead, a complex mechanism which involves the interaction of people. (Creighton, Jolly, Denning, 1972, p. 3)

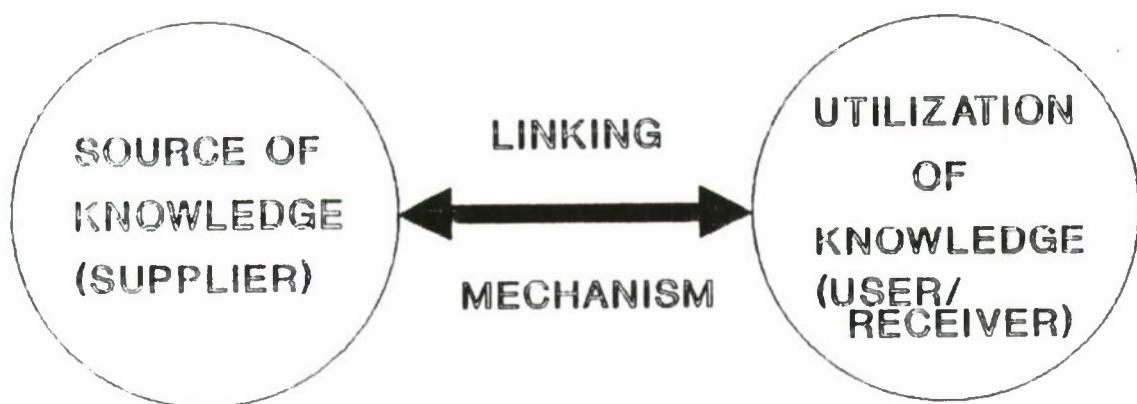


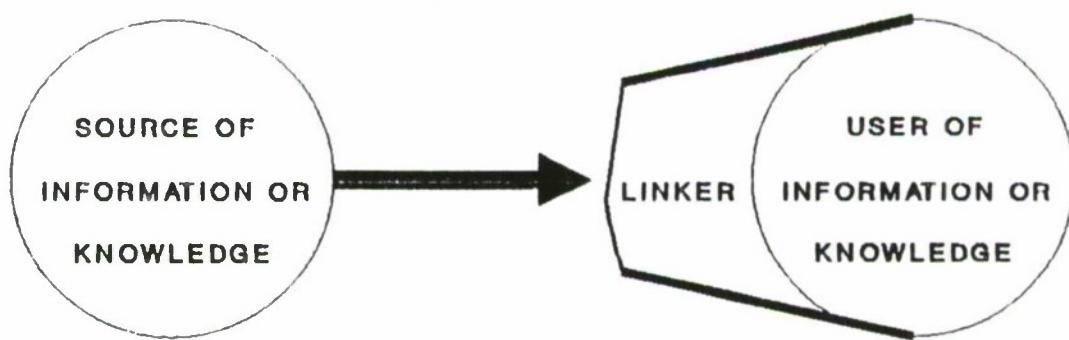
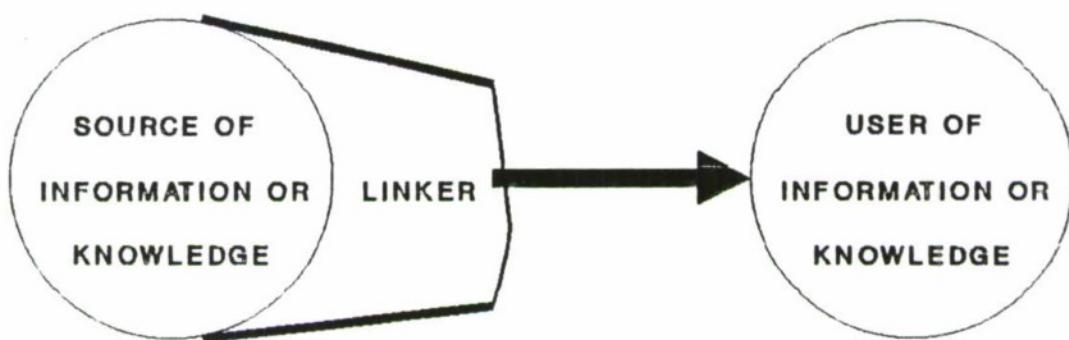
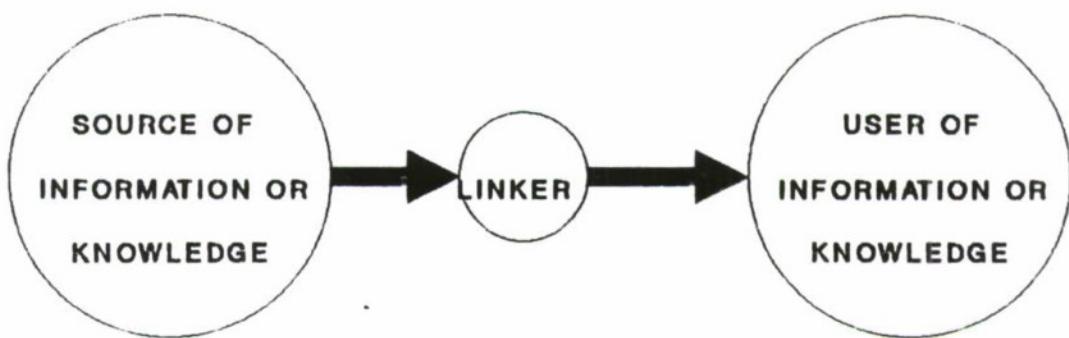
Figure 8. A Simplified View of the Linking Mechanism

A basic ingredient contributing to the rapid, widespread acceptance of JOTS is finding those people who can serve as liaison between the technical expertise of the developers of the system and the users/operators of the Navy. These liaisons are comparable to the linkers addressed in technology transfer studies (Jolly and Creighton, 1971). The linker is essentially the individual or group of individuals who operate

as a coupling device between the source of knowledge (supplier) and the application/utilization of the knowledge (receiver). The linker could be associated with the source, the user, somewhere in between as an independent group (consultant), or at both ends (Figure 9). Most literature is inclined to support the linker as more appropriately a member of the user team. However, some view the linker position in the flow of knowledge less literally and tend to place the linker in the middle not because a separate group exists but because the "linker" is not an individual. The linker, in this case, is viewed as a "synergistic effect of all the people in the communicating chain from transmitter to receiver." Linkage occurs when mutual excitation between any of these people occurs as their immediate values match if only for that particular transfer event. (Essoglou, 1975, pp. 8-9)

Whether the INRI/Navy personnel serving in this capacity are in fact effective linkers, having "linker-type" qualities is difficult to prove. "It is not always possible to identify a person as a linker, or to find out after a linkage has occurred, how it occurred and who it was that caused it to happen." (Creighton, Jolly, Buckles, 1985, p. 73) However, the qualities associated with "linker-type" people are listed in Figure 10.

Linkers tend to be innovative--introducing new things or ideas. Venturesomeness being a general attribute of the



Source: (Jolly and Creighton, 1975, p. 8)

Figure 9. Linker Positions in the Flow of Knowledge

Innovative
Willing to Accept Risk
Active in Multi-disciplines
More Information Contacts
High Credibility With Peers
Cosmopolite
Oriented Towards Outside Information Sources

Figure 10. Attributes of Linkers

innovator, they have a favorable attitude toward the risk associated with a new innovation. Linkers have great exposure to interpersonal and mass media (radio, newspaper, magazine, TV, etc.) communication channels. Possessing high credibility with their peers affords linkers with a high degree of opinion leadership. Linkers are cosmopolite--oriented toward something which is greater than the limited local environment. Being active in multi-disciplines, they are more likely to attend conventions, be interested in new things, belong to special organizations and have personal contact with individuals outside their own group.

Likewise, there are some identifiable attributes present in the INRI/Navy liaison individuals which tend to enhance their ability to "link." A considerable portion of INRI personnel have had some prior Navy experience, greatly increasing their credibility from the user's point of view.

INRI has developed an organization of top-level management with a great deal of previous naval experience (O-5 through O-7), able to see the big picture and relate with those currently holding similar high level naval positions. These men have the necessary experience enabling them to effectively work both the ship and the shore station problems. They know how to talk with the naval officers as well as the enlisted personnel. As the number of JOTS installations grew and more installers/trainers were required, INRI hired some OS's (operations specialists) following completion of their naval commitment--home-grown linkers. These installers/trainers joining the INRI organization directly from an OS billet are in a uniquely ideal position to relate to the abilities, capacities and concerns of the current naval JOTS operators. But for all of INRI's previous naval experience, they do not recruit from the Navy. INRI understands the need for capable people to remain in the service. They are as valuable to INRI in place as they might be if they opted to leave the service and came to work for them. With the right people in the right places, JOTS development continues.

C. CONFIGURATION MANAGEMENT

The accelerated development cycle of JOTS is fed by an effective method of determining requirements and recommending solutions which are architecturally sound and implementing these solutions quickly and accurately. Configuration management must be maintained.

Configuration management is the discipline of ensuring equipment or hardware meets carefully-defined functional, mechanical and electrical requirements and that any changes in these requirements are rigidly controlled, carefully identified and accurately recorded. (Stephanou) Configuration management may be defined as "the process that identifies the functional and physical characteristics of an item during its life cycle, controls changes to those characteristics, and provides information on the status of change actions." (Systems Engineering Management Guide, 1989, p. 6) On whether or not changes should be made, Graham (1970), as quoted in Roberts' (1987) NPS thesis on U.S. Naval Ship configuration management, says,

A middle ground somewhere between the excessive issuance of changes and no changes at all would probably be best, though. And the answer is Configuration Management. Properly administered, the configuration management program should result in an optimum situation with respect to changes, economics and the ever advancement in the state of the art. (p. 1)

In 1984, the only configuration management for JOTS development was in the Newport News office with Dr. Frank Engel doing the entire job. While the system was still limited in distribution, this was pretty well manageable. When under the AIRLANT contract, the CNAL staff made an effort to keep track of the various configurations installed on its aircraft carriers. Dr. Engel obtained CNAL approval for major system changes, though not necessarily for debugging and minor changes. If one staff wanted something new or a change, it

was tested on their system and left aboard if successful. The change was then tried on another carrier staff to see if it was generally acceptable. If so, CNAL put their stamp of approval on it, and it had the change instituted on all remaining carriers. It was a rather loose way of managing, but in a rapid prototyping mode and with a limited number of ships (carriers) it worked reasonably well.

The CINCLANTFLT configuration management (CM) board was later established with the responsibility for Navy installations, afloat and ashore, for both fleets. This CLF CM board does not approve the JCS configuration nor are they in any way involved in whatever configuration is provided for any other service.

With respect to JCS (CINC's) systems, the configuration is recommended by INRI and approved incrementally by the J6 staff. The Fusion Net (all integrated systems) may not be identically configured at any point in time, but upgrades are generally installed on a schedule with target dates prior to scheduled major Naval exercises when all systems should be configured alike.

As installations became more numerous throughout the Navy there became an increasing awareness of the need for centralized configuration management. The function has definitely grown beyond the scope that one person can responsibly manage. There may come a time when the need is seen for a JOTS configuration management board with the

ultimate responsibility of all JOTS systems; Atlantic Fleet, Pacific Fleet, JCS, all services, and all allies. However, this increased authority and responsibility of a configuration management board does not signal the end of rapid prototyping. Ruckert correctly states that configuration management is intended to control configuration changes, not prevent them. (Navy Program Managers Guide, 1988, p. 4-88)

Changes will always be necessary to enhance design attributes such as reliability and maintainability, to correct latent design deficiencies discovered by ongoing test and evaluation, to utilize applicable new technology and to accommodate changing tactics and new threats. As long as changes are carefully and centrally controlled and accounted for in the management system, they can significantly enhance the utility of the evolving system.

D. AGGRESSIVE USER SUPPORT

Users/operators are informed and kept apprised of changes, problems, status of upgrades, etc. User input is sought in an operational forum during actual use or lack of use of the system. There is no substitute for face-to-face operator-technician interface in the very operational environment for which the system is being designed. Operators can literally demonstrate any problems or concerns they see in utilizing the system to complete required tasks. Technicians can begin working on a solution comfortable in the knowledge of full understanding of the system problem as perceived by the

operator. In addition, being receptive to innovations advanced by sailors will nurture their self-motivation. The operators aggressive support has become a mainstay in assisting in the development of an improved battle management system.

E. COORDINATION AND PLANNING

Rapid turnaround of software and hardware must be accompanied by advanced planning and coordination that appears well-thoughtout and thorough to the users. Knowing that a particular system change is being implemented at a given time towards integrating specific improvements reduces much operator tension in the wake of "yet another update."

F. ACCELERATED PROCUREMENT CYCLE

Expedited procurement methods are used to procure required hardware in time for operational use of the system. The budget process is too cumbersome for a program which is needed in the fleet on short notice. In view of the short software lifecycle, the system would be outdated before it gained approval. Dr. Stuart Starr (1989) of Mitre Corporation, in a presentation to a Systems Engineering class at the Naval Postgraduate School, reported that expected technological obsolescence of hardware is three-five years, system software is five-ten years, and application software is five-20 years (p. 26).

If forced to go through normal PPBS channels, JOTS would require anywhere from three to eight years to make it from concept to fleet installation, and only after it had gone through the usual concept stage, initial testing of the concept, lab testing and OPTEVFOR acceptance. COMNAVAIRLANT, recognizing the inherent time delay, became a strong supporter of the system and used their own operating funds to support the program. CINCLANTFLT would also frequently "beg, borrow, and steal" funds to buy equipment using funds previously earmarked for existing projects such as baseline upgrade, CINC initiative, and command center improvement since JOTS was not yet a budget line item with its own specifically designated resources.

G. ACCEPTANCE TESTING CRITERIA/PROGRAM

Users require a method of verifying that software performs desired functions to their satisfaction. Acceptance testing is accomplished by means of advanced test design during development and successful certification before delivery. Tests are then repeated onboard to satisfy users and accomplish training in the process.

H. INSTALLATION/MAINTENANCE SUPPORT PACKAGE

Documentation supports the hardware maintenance and installation guidance. Installers work with the representative from the naval unit who will be trained during installation, as no formal school exists. Explicit

installation/maintenance training is paramount in a military organization. Those operators initially trained by the developer's installers must gain a degree of understanding sufficient for them to train subsequent incoming personnel. With only two- or three-year tours of duty, there is no corporate knowledge without constant passdown as routine personnel rotation continues.

I. TRAINING/IMPLEMENTATION

The most important element of rapid prototyping is successful training of new functions and capabilities available in the system. Successful is the key here. To simply have additional capabilities that only the developers can operate is not truly a system improvement at all. Once the operators have mastered a new function, then the system capability actually rises. This is roughly akin to the concept of information transfer not actually taking place until the receiver utilizes his new-found knowledge.

Training covers both operators and maintenance personnel. Operator training concentrates on implementation schemes. These techniques frequently require staff/ship consent. At this point, top level support is required if full system capability is to be realized.

J. LIFECYCLE SUPPORT FOR MAINTENANCE/TROUBLESHOOTING/UPGRADING

The operating unit must know they have a well-defined place to turn for solutions to problems and that quick

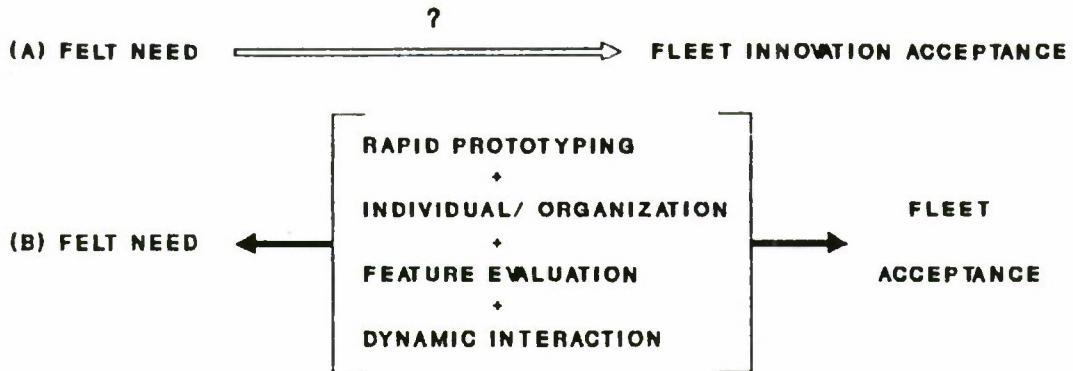
response will be available. A rapidly evolving system has little reference documentation when in a constant state of change. Currently, configuration management schemes are facilitating development of proper system documentation, as much as that is feasible given the dynamic nature of accelerated development. Additionally, INRI representatives are accessible to users at any JOTS equipped facility via internal system communications.

V. DESCRIPTIVE INNOVATION IMPLEMENTATION MODEL

Based on a review of the literature, data from interviews and correspondence with various "players" in innovation acceptance, and first-hand observation, a descriptive model of rapid prototyping innovation implementation (RPII) is developed in this chapter. The RPII model attempts to answer the question posed in Figure 11a--what components are necessary to enable a felt need to be successfully translated to fleet acceptance of an operational innovation? Those components, as listed in Figure 11b, include:

- (1) a rapid prototyping component.
- (2) an individual/organization component.
- (3) a feature evaluation component.
- (4) a dynamic interaction component.

All components must be thriving simultaneously in order to achieve the desired innovation implementation. Figure 12 details the critical aspects within each component and is explained in detail in the rest of this chapter. Some overlap necessarily occurs as is to be expected when dissecting any interrelated process into segregated parts. The rapid prototyping component has been described in detail in the preceding chapter. The three remaining components will now be similarly addressed.



Source: Author

Figure 11. RPII

Following discussion of the contributing components, the remaining section of this chapter presents the RPII model as a schematic overview. The model is described in a general manner intended to be applicable to many kinds of organizations involved in technology transfer, as well as specifically to accommodate JOTS rapid prototyping innovation acceptance as observed in the Navy.

A. INDIVIDUAL/ORGANIZATION COMPONENT

Just as one cannot accurately assess a system without considering each distinct part, one cannot evaluate an organization without considering each individual. Individuals bring with them a set of attitudes, beliefs and values based on their previous experience. Additionally, as an entity, organizational members have a shared set of attitudes,

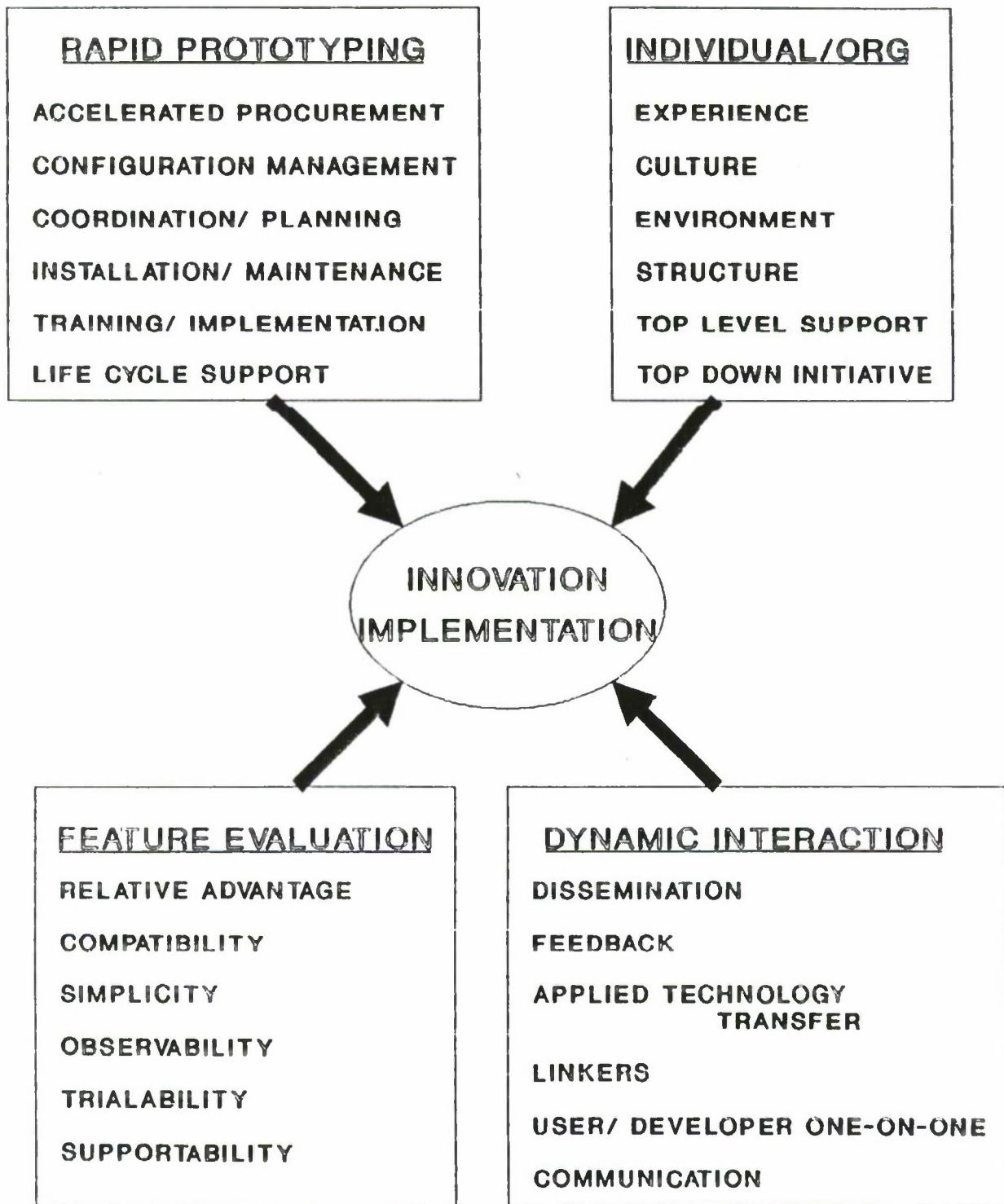


Figure 12. Innovation Implementation Components

beliefs, and values. Such values, along with norms and traditions, contribute to make up the culture of an organization.

The individual and organizational attitudes, norms, and culture create an environment which may or may not lend itself toward innovation acceptance. Bennet et al. (1967) described three types of organizations with regard to their propensity to adopt technology:

- (1) Innovative firms--technical, progressive, constantly seeking out leading-edge technology, intelligently accepting inherent risks in being a leading firm in adopting new technology and innovating.
- (2) Adoptive firms--committed to staying aware of current trends in their present and closely related market areas, little energy or resources committed to first-hand searches for new technology, capitalize on proven advances of competitors in the form of process improvements.
- (3) Resistive firms--highly complacent, unwilling to be concerned with advancing technology, committed to a policy of maintaining the status quo. (p. 24)

Obviously, the innovative firm would have the highest potential for utilization of new technology.

Digman (1977), citing Mohr (1966), stated that the existence of an organic management system--an informal network type of management rather than the traditional hierachial structure of authority--may have a beneficial effect on the incidence of innovation. There is also evidence that a project-oriented organizational structure encourages more innovation than do more conventional, functional forms of organization (Wilson, 1963).

No matter what the structure, it seems obvious that top-level support is a must if an innovative effort is to progress through implementation to the institutionalization phase. Lack of active support at high levels within an organization can put an end to an innovative effort either actively or passively. In some cases, simply not acting at all may be enough to stop an initiative. Alternatively, termination of sufficient resources (equipment, funds, personnel, etc.) or authority may likewise end a change effort.

On the other hand, top-level support can be the vital asset that keeps an organization in a proactive state. Lending unlimited support and all that is feasible of realistically limited resources can have a measurable, positive impact on the effective implementation of an innovation. No form of project support could be any greater than for top-level management to actually initiate the project. Given that the project is indeed feasible, a top-down initiative has great potential for being ultimately seen through to completion if at all possible.

B. FEATURE EVALUATION COMPONENT

In addition to individual and organizational factors, user adoption and acceptance of a specific innovation is influenced by the perceived features of the device itself as evident in the literature. These innovation-specific features are subjectively evaluated by users profoundly affecting user acceptance (Mackie et al., 1972). Consequently, the model of

the rapid prototyping innovation implementation process includes a component which reflects specific features of innovations including:

- (1) relative advantage.
- (2) compatibility.
- (3) simplicity.
- (4) observability.
- (5) trialability.
- (6) supportability. (Canyon Research Group, 1982, p. 62)

Relative advantage is the degree to which an innovation appears better than the idea it supercedes from the user's perspective. The greater the relative advantage, the more rapidly the innovation is adopted (Rogers and Shoemaker, 1971).

Compatibility, also positively related to rate of adoption, is considered in two respects. First, compatibility is the degree to which an innovation is seen by users to be consistent with the existing values, past experience, and needs of the user. Secondly, an innovation must be operationally compatible with other systems with which it must work.

Simplicity is the degree to which an innovation is relatively easy to understand and use as perceived by the users. Simplicity within realistic considerations is a highly desirable feature. However, if users perceive a problem has been oversimplified to the point of compromising real-life

complexities, relative advantage is sacrificed (Canyon Research Group, 1982, p. 63).

Observability is the degree to which the results of an innovation are visible to others including the time before adoption through acceptance or rejection of an innovation. This seems particularly important in acceptance of products about which there is some initial skepticism.

Trialability is the degree to which a potential user may experiment with an innovation prior to adoption and/or acceptance. This opportunity for hands-on experimentation is obviously seen as positively related to the rate of adoption.

Supportability extends the behavior of user acceptance throughout the life of the innovation. Innovations which offer relative advantage, compatibility, simplicity, observability and trialability may still, ultimately, experience rejection if the features of the innovation cannot be maintained in a favorable condition due to design deficiencies, logistical support deficiencies, lack of timely updating, etc. (Canyon Research Group, 1982, p. 64).

C. DYNAMIC INTERACTION COMPONENT

Any model which attempts to deal successfully with technology transfer involving only a "giver" of innovative information to a "receiver" is bound to overlook some of the important organizational interactions and necessary feedback processes which bear upon research utilization and acceptance.

How well and how much research transitioning takes place are ultimately effected by the dissemination and feedback processes between researchers and users. Members of research producing communities have a tendency to disseminate their findings to other members of the same community. However, dissemination of findings to the user community is often seen by other researchers as going well beyond scientific qualifications of findings and their meanings. Likewise, potential users tend to rely more on their own personal experience and that of their colleagues than on research results. With these sheltered perspectives in mind, it is no mystery why much research is never transitioned into use.

Similarly, the feedback process from user to research producer can be very attenuated. Researchers frequently find their research problems in conceptual and empirical literature in academic journals rather than by engaging in dialogue with practitioners. Thus, input by users in the beginning of the research production process is limited both by the virtue of researchers' natural inclination as well as by frequent indifference on the part of the potential users. If practitioners do attempt to make use of research findings, their experiences with such attempts do not necessarily get fed back to those who originated the research. The feedback loop, therefore, very frequently never gets established in the research production/utilization cycle.

Fortunately, these potential pitfalls can be avoided through the application of technology transfer theory. "Linkers" can play a significant role in ensuring that developers and users are indeed headed in the same direction with respect to a new innovation. Direct user/developer face-to-face interaction can not always realistically be achieved but, when possible, saves much time and energy of all concerned. A short hands-on demonstration of an innovation problem/shortcoming from the users' perspective may save countless manhours attempting to express the same problem in written terms which connote the users' concerns in a language the developer can interpret into an appropriate innovation modification.

There is no substitute for good communication within or between organizations. On this subject, Porter et al., states that the process would be facilitated,

...if researchers and users could establish stronger and more frequent links, if individuals in potential linking roles...could be better utilized by both researchers and the organizations for which they work, if research results could be brought to bear in a more timely fashion on the problems faced by users, and if research findings were reported in ways more consonant with user interpretive frameworks. (NPRDC, 1986, p. 25)

D. INTERPRETATION AND ANALYSIS

Rapid prototyping, individuals and organizations, feature evaluation, and dynamic interaction are all a part of successful innovation implementation. Figure 13 presents a schematic overview of the RPII model encompassing each of the

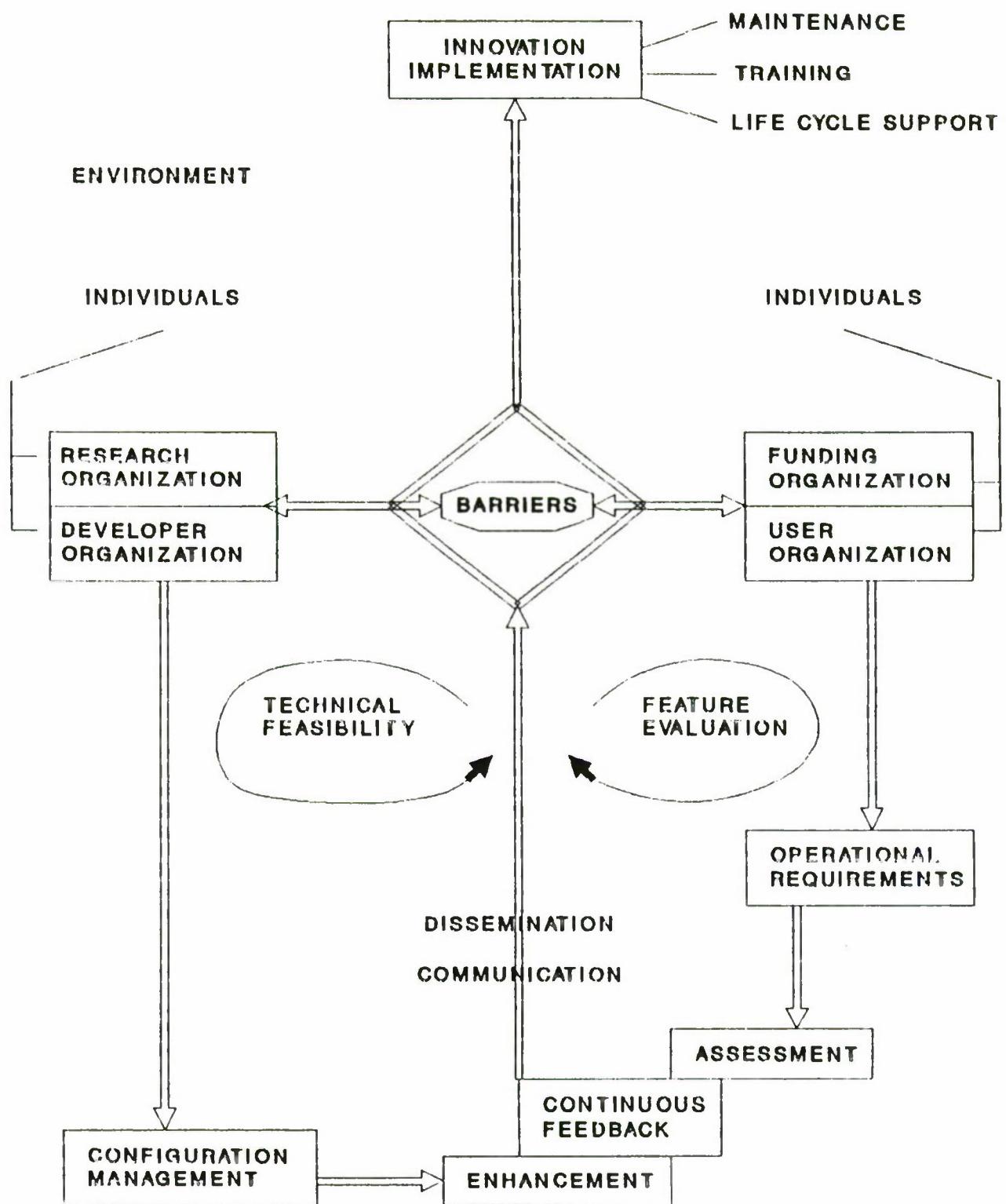


Figure 13. RPII Model

components discussed as they apply to the process of planned change. The figure is described in the remainder of this section.

As depicted and previously discussed, it is important to keep in mind that both the developing and user organization are made up of individuals. These individuals affect the organization to varying degrees singly and as members of formal and informal subgroups within the organization. Some groups may have a considerable amount of influence on the attitudes and values of the organization as a whole.

It is essential to be aware of any such influential groups within the other organization involved in the research/utilization process. Given proper consideration, these groups may create pockets of commitment in favor of an innovation as opposed to resistance to change against an innovation.

In the JOTS case study, used as the illustrative example of rapid prototyping in the Navy, there are only two organizations to be considered. However, there is the potential for at least four independent organizations to be involved: research, developer, funding, and user organizations. These four organizations meeting head-on will be challenged by a number of potential barriers to change. But these barriers need not stop the innovation implementation process. Not all barriers can be completely eliminated, but just being aware of them may help an organization minimize their effects. Resources in all likelihood will be limited,

so plan accordingly. Objectively evaluate the overall feasibility of the project as planned--including technical aspects, time permitted for each phase, and funds available. Other barriers include actual and perceived degrees of willingness and capacity to accept change, capability to utilize the proposed change, and credibility of one organization's members as viewed by the other.

The very nature of the rapid prototyping process will serve to minimize the effects of many of the previously mentioned barriers to technology transfer. The cyclical nature of the rapid prototyping process takes advantage of gradual, incremental progress in willingness and capacity to accept change, proven credibility of members and increased capability through continued familiarity and training opportunity. The user organization determines the operational requirements for the new innovation and assesses the functionality of the developer's system as designed. The developer organization, based on user assessments, designs and redesigns the system introducing incremental improvements corresponding with the user's new and/or changing requirements. The developer also must ensure that subsequent system enhancements are controlled and managed through responsible configuration management.

The success of this continual assessment-enhancement cycle is dependent upon continuous feedback if indeed an operationally useful innovative system is to be produced.

This face-to-face developer/user interaction serves as a great facilitator of information exchange. Linker-type characteristics may prove helpful in this interchange between organizations to ensure that differing perspectives and perceptions are not contributing to misinterpretation from/to the realm of user/developer. Face-to-face interaction, in itself, does not guarantee good communication; however, it does guarantee the opportunity for continued communication. Over time, users and developers can grow to appreciate the expertise of the other within their own area of interest. Eventually, the ongoing task of translation of user assessment to developer enhancement can become increasingly familiar and thorough for both parties.

Another important aspect of rapid prototyping is that the user is quickly afforded the opportunity to become familiar with the innovation. Feature evaluation could not be any easier. Observability and trialability are at a premium. Compatibility can be directly demonstrated in the user's actual workplace. And, relative advantage of the new innovation over previous practices can be evaluated side-by-side.

Through the repetitive cycle of events with continued dissemination of information and continued communication among and between organizations, innovation implementation can be realized well within time, funding, and personnel constraints. Such repetition and interaction facilitates prolonged

operational training and continuity withstanding the perpetual mobility of military personnel. The developer organization is, by definition, available for the duration, for training, maintenance, and life cycle support. In turn, this lasting personal interaction can lead to innovation institutionalization even within an organization as vast as the United States Navy.

VI. CONCLUSIONS AND RECOMMENDATIONS

The Navy is increasingly dependent upon the use of complex software intensive devices for the achievement and maintenance of operational readiness. As the scope of the missions of these devices has increased, so has the cost of procurement, maintenance and utilization, placing increased importance on effective research, development, and use.

There is considerable doubt that the Navy's research effort related to C3 innovations is achieving its full potential impact. There are substantial differences of opinion concerning the most cost effective design of such software intensive devices and how best to incorporate innovative developments into those designs. This results in problems of acceptance on the part of both individuals and Navy organizations, whether they are concerned with the design, development, or use of the innovative device.

In an effort to move toward a solution to these problems, research was conducted to develop a model of factors influencing user acceptance and organization implementation. The model reflected a review of the literature on implementation of change, innovation acceptance, organizational development and human factors in technology transfer; a review of related Navy-specific findings and the elements of rapid prototyping; a case study of INRI's JOTS

evolution as a real world example of rapid prototyping innovation implementation; and interviews and correspondence with personnel representing "players" in the development and utilization process.

The development of a descriptive model of rapid prototyping innovation implementation (RPII) led to several conclusions. The model should incorporate four major components: a component intended to reflect rapid prototyping, individual/organization, feature evaluation and dynamic interaction. The RPII model should permit explicit representation of interactions among all the organizations that are involved (researcher, funder, developer, and user).

If the goal is indeed to transition research to the user, recommendations for improvement of the process include:

- (1) Research should be conducted in response to identified needs of potential users, by potential users.
- (2) Organizations should be willing to consider and implement new ideas or initiatives on their own merits, regardless of the organizational level in which they originate or even if they come from a source outside.
- (3) Full communication through all stages of the research and development process from original research to ultimate application is a necessity.
- (4) The determination of technical approaches to problems should be done by technical people, and the input of technical information to the decision process should come as directly as possible from the people who are actually doing the work regardless of their position in the organization.
- (5) There is a need for more direct focus on the transitioning process; mere awareness of potential facilitators and barriers to change could help to optimize the benefits of an innovative effort.

Probably no single approach to improving the research transition process is likely to be uniquely successful. However, this model is useful in structuring thinking about the problems of innovation implementation. It may also be useful in identifying organizational processes that might benefit from change and in identifying areas where future research on the acceptance process may have the greatest impact.

Further research could conceivably be applied to comprise a weighted linear combination of the components and their related factors, at least a first approximation. Efforts could be made to quantify at least some aspects of the model, to assess its utility and to attempt to produce results which may be applied directly to solve or reduce some of the practical problems of innovation implementation identified during this study.

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